metal atment

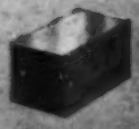
Vol. 25 : No. 158 NOVEMBER, 1958 Price 2/6

ELECTEM

DIE BLOCKS

SOMERS

We specialise in die blocks; our modern die plant is designed exclusively for the production of die blocks of unvarying excellence.



WALTER SOMERS LTD. HAYWOOD FORGE, HALES OWEN Nr. BIRMINGHAM

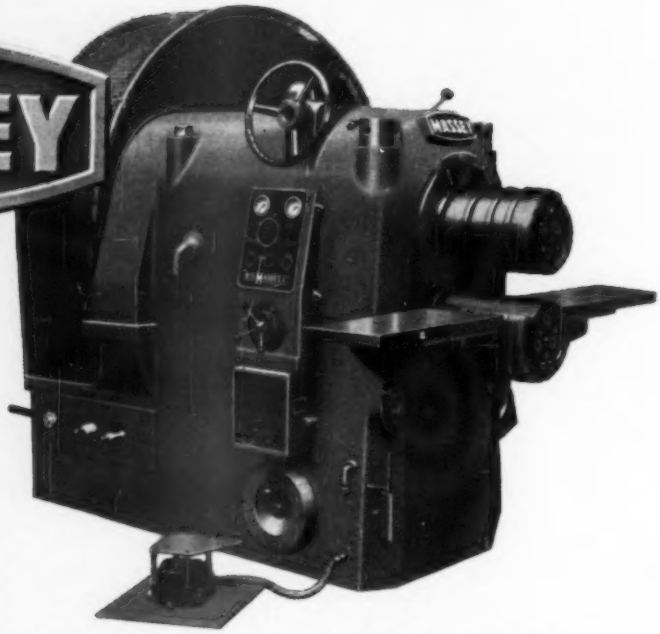
TELEPHONE: HALES OWEN 1185

SAVE MATERIALS MAN-HOURS

WITH

MASSEY

USE-ROLLERS



Rolling is now accepted as an excellent method, quick and cheap, of preparing material for drop forging, particularly in the case of long, thin, uses. Rolled uses cut out fullering, edging or forming and are clean, descaled and without flash. The material is accurately distributed, no operating skill is required, and time, labour and material are saved. The machine is portable, needing no permanent mounting or foundation and can therefore be placed just where it is wanted.

Massey designs include :—
Steam and Compressed Air Hammers, Pneumatic Power Hammers, Friction Drop Hammers, Double-acting Steam and Compressed Air Drop Hammers, Forging Presses, Trimming Presses, Tyre Fixing Rolls.

FEATURES OF THE MASSEY USE-ROLLERS

- Quicker and more positive roller adjustment
- Control and operation by foot pedal or automatic trip as required
- Well proved direct air operated friction-type clutch
- Automatic flood lubrication
- Central panel provides quick and easy control of motor, single or continuous action, and over-run adjustment

B. & S. MASSEY LTD. OPENSHAW · MANCHESTER · ENGLAND

MAKERS OF THE WORLD'S GREATEST RANGE OF FORGING PLANT

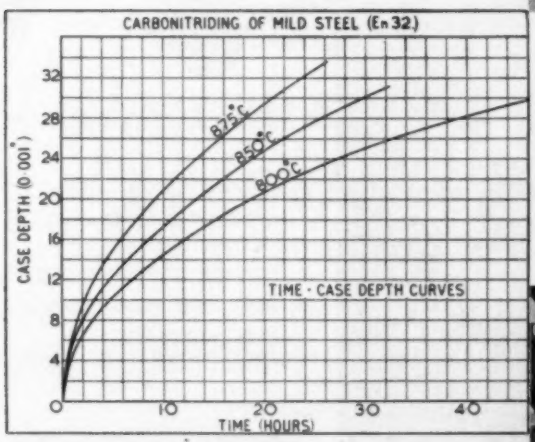
WILD BARFIELD CARBONITRIDING

. . . the best in every case

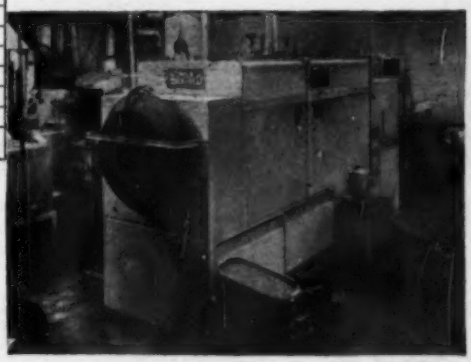
CONSIDER THESE POINTS:

- Clean working conditions
- Unskilled labour may be employed to carry out the process
- Post-cleaning operations reduced
- No storage space required for case hardening materials
- Simple system of atmosphere control

Shaker hearth furnace



- Atmosphere employed is raw Town's Gas and Ammonia
- No costly gas preparation plant required
- Batch or continuous equipment
- Consistent repetitive results



Rotary drum furnace

ELECTRIC WILD BARFIELD FURNACES

FOR *ALL* HEAT-TREATMENT PURPOSES

WILD-BARFIELD ELECTRIC FURNACES LIMITED

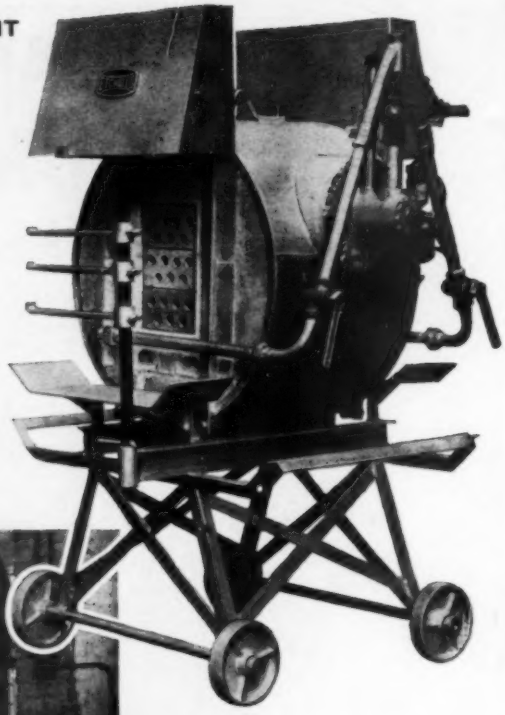
ELECFURN WORKS · OTTERSPOOL WAY · WATFORD BY-PASS · WATFORD · HERTS · Telephone: Watford 6091 (3 lines)

WB54

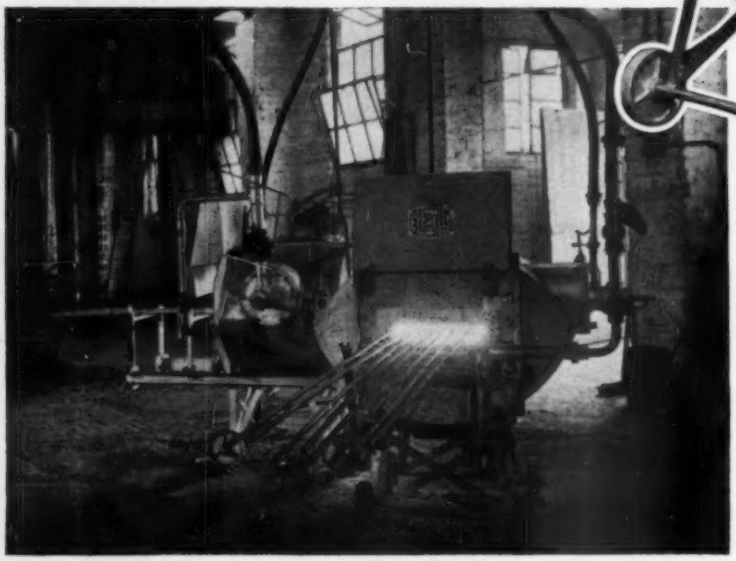
FORGE, GALVANIZING & HEAT TREATMENT FURNACES, DRYING OVENS, ETC.

FURNACE ETCHELLS ENGINEERS

UP TO 20% FUEL SAVING.
SMOKELESS COMBUSTION.
NO UNCONTROLLED AIR.
MODERN EFFICIENT DESIGN.
SIMPLE CONTROL,
AUTOMATIC OR MANUAL.
COMPLETE INSTALLATIONS.
TECHNICAL & ADVISORY SERVICES.



Oil-fired Bolt or Pin Forge Furnace



CLEAN ATMOSPHERE.
IMPROVED OPERATING CONDITIONS.
LOWER RUNNING COSTS.
REDUCED MAINTENANCE.
LESS WASTAGE,
AND INCREASED OUTPUT.

Oil-fired Slot Type Forge Furnaces

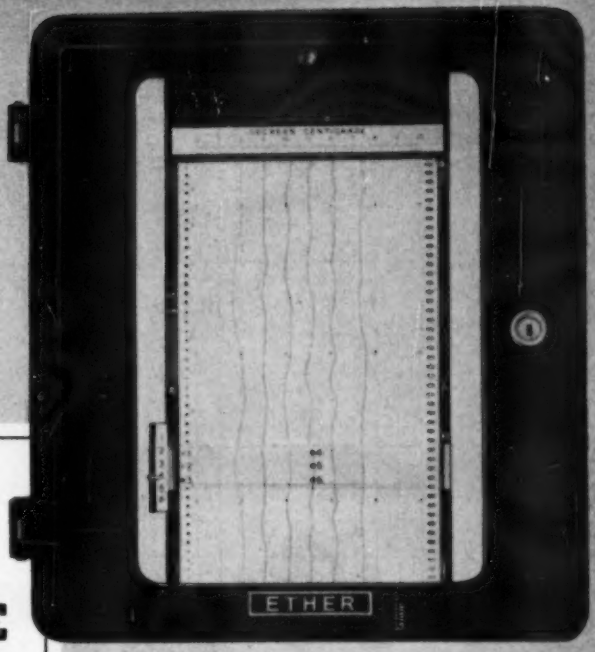
DAVID ETCHELLS & SON LTD

FURNACE DIVISION

DARLASTON S. STAFFORDSHIRE

TELEPHONE: JAMESBRIDGE 2067

Completely New!



ETHER

TEMPERATURE RECORDER

TYPE 800

★

Single or multi-point

★

Exceptional accuracy

★

6" Calibrated chart

★

Many refinements

This new Recorder is an instrument of the highest quality. It records any number of independent temperature points from one to six with exceptional accuracy.

Special features include: chart speeds of 1 in., ½ in. or 2 in. per hour; an automatic rewind-ribbon-mechanism; fully-compensated galvanometer; an entirely new scanner commutator; and a hinged chassis for quick, easy, inspection and servicing.

ENQUIRIES, SALES & SERVICE:

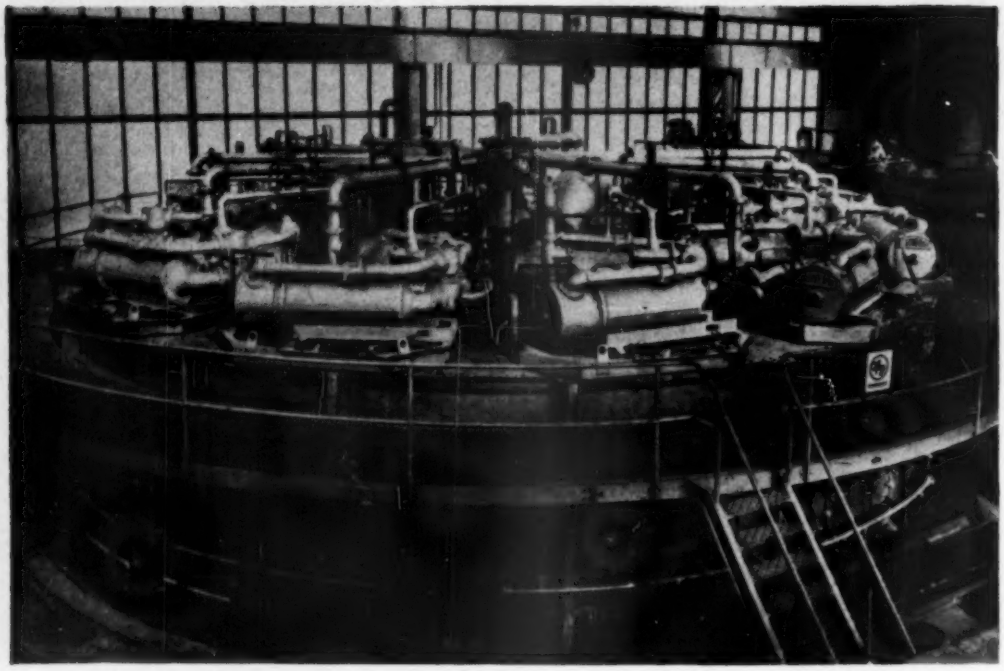
Tyburn Road, Erdington, Birmingham, 24
East 0276-8

Caxton Way, Stevenage, Herts.
Stevenage 780-4

Representatives throughout the U.K.
Agents in all principal countries

ETHER LIMITED

TEMPERATURE & PROCESS CONTROL EQUIPMENT FOR ALL INDUSTRIES



Rotary Hearth Furnace. Output 10 tons per hour

£2,000,000 a week

that is what the British Steel industry can save by eliminating scale in reheating furnaces.

that is what Equiverse can save.

An Equiverse furnace is direct-fired, yet it gives absolutely clean and scale-free heating up to 1,300°C. Although it is a controlled atmosphere furnace, heating rates are high.

Bulletins V.30 and V.54 explain how Equiverse can help you.

INCANDESCENT

THE INCANDESCENT HEAT CO. LTD., SMETHWICK, ENGLAND

9/1/58

The **EXPERIENCE...**

. . . gained in supplying
Drop Forgings
in special creep-resisting
Alloy Steels
and 'Nimonic' nickel alloys
for gas turbines
since the first Whittle engine,
is at the disposal of
Gas Turbine designers
and manufacturers.

A Main Supplier
of drop forgings
to British and European Manufacturers
of Aircraft Turbo-Jet
and Turbo-Prop Engines,
we are also active in the field of

INDUSTRIAL GAS TURBINES

and of

COMPOUND DIESEL-TURBINE ENGINES

and

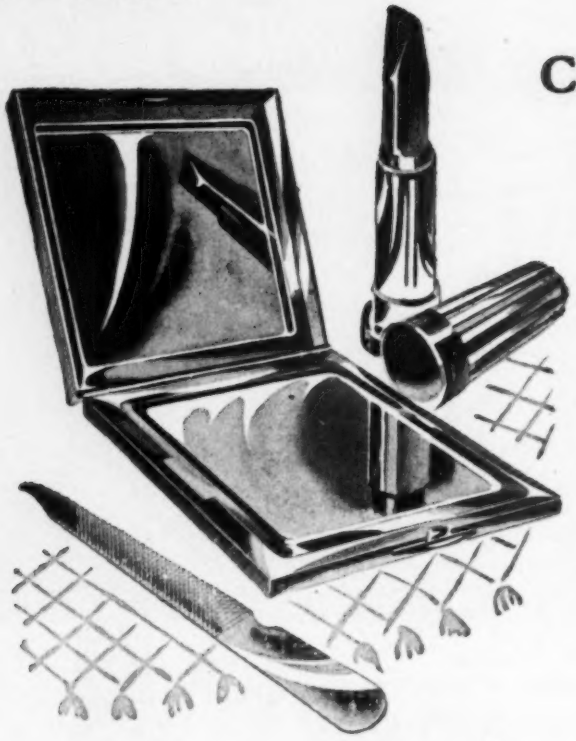
FREE PISTON-TURBINE ENGINES

A 16mm Colour Film with sound commentary, entitled 'Drop Forgings in Alloy Steels,' is available on request.

FIRTH-DERIHON

SHEFFIELD & DARLEY DALE

THE FIRTH-DERIHON STAMPINGS LTD. · SHEFFIELD · ENGLAND



Cold rolling comes into this picture

Hard steel strip for a nail-file, or a non-ferrous alloy for my lady's toilet requisites—there's a size and type of steel roll which is the right one for the cold rolling operation involved. Doncasters can, and do, make rolls suitable for cold rolling any product.

DONCASTERS ◇
1778 D D

HARDENED STEEL ROLLS

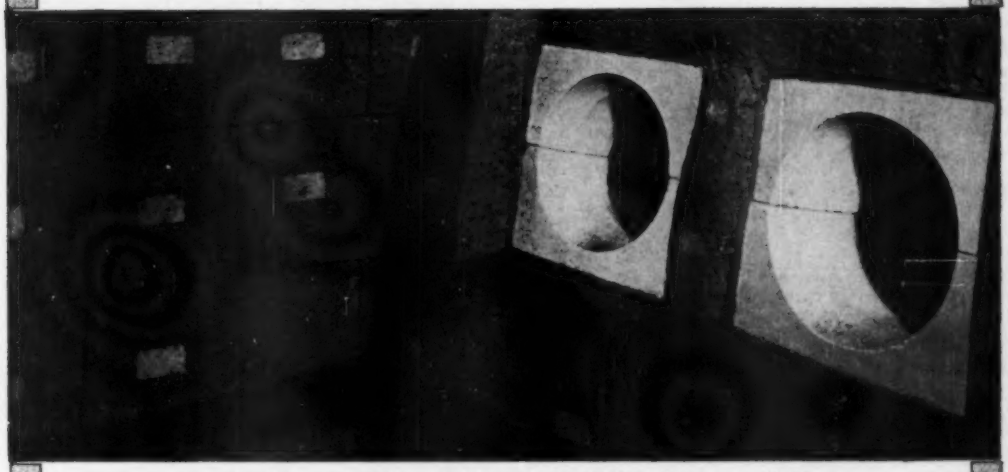
We make hardened steel rolls of all sizes from those weighing only a few pounds to the big ones weighing several tons. Each roll receives special consideration in our works and is planned exactly for the duty it has to perform.

DANIEL DONCASTER & SONS LIMITED · · SHEFFIELD
FORGINGS · DROP FORGINGS · HARDENED STEEL ROLLS · HEAT TREATMENT

R.28

Tri-Mor Plastic & Castables

MAKE INSTALLATION EASIER, QUICKER AND CHEAPER



Front and side walls of a Queen Mary boiler in Tri-Mor High Temperature Mouldable, with MR 60 anchors. Burner quarls in Tri-Mor High Temperature Castable.

TRI-MOR GRADES

TRI-MOR *Standard Castable*
A medium texture refractory having negligible shrinkage up to 1,350°C. Suitable for casting special shapes or for monolithic structures. Limiting service temperature 1,350°C.

TRI-MOR *High Strength Castable*
A similar refractory to Tri-Mor Standard Castable, but specially developed to have very high mechanical strength over the lower temperature range. Maximum service temperature 1,250°C.

TRI-MOR *High Temperature Castable*
Suitable for face temperatures up to 1,600°C; has an extremely high resistance to thermal shock; used for cast in situ monolithic structures and for pre-cast refractory shapes; can be applied with a cement gun.

TRI-MOR *High Temperature Mouldable*
A plastic refractory for use up to 1,650°C: low shrinkage and a high resistance to spalling. Supplied mixed to the correct consistency for installation.

TRI-MOR *Dense "Guncrete"*
A hydraulic setting refractory with a maximum service temperature of 1,300°C. It has a high resistance to abrasion. Designed for application by cement gun, but can be trowelled.

TRI-MOR *Insulating Castable*
An insulating castable for maximum service temperatures of 1,200°C; low thermal conductivity is its main feature.

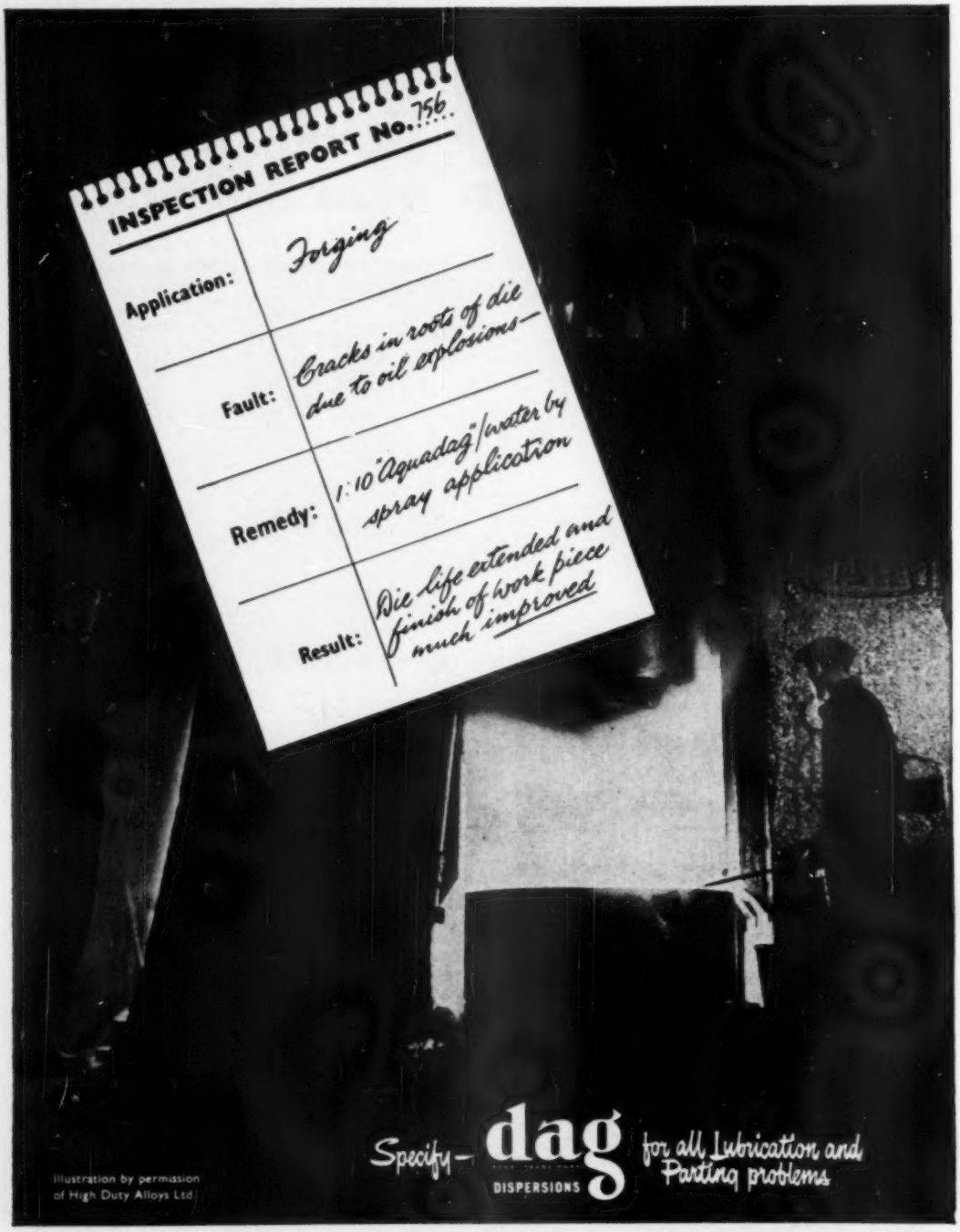
TRI-MOR *Insulating "Guncrete"*
Similar to Tri-Mor Insulating Castable but for application by cement gun.

Full details of each grade are available on request.

MORGAN Refractories Ltd

For further information please write to: MORGAN REFRACTORIES LTD. NESTON, WIRRAL, CHESHIRE. TEL: NESTON 1406

NE 138


INSPECTION REPORT No. 756
Application: Forging
Fault: Cracks in roots of die due to oil explosions—
Remedy: 1:10 "Aquadag"/water by spray application
Result: Die life extended and finish of work piece much improved
Specify— dag DISPERSIONS for all Lubrication and Parting problems
Illustration by permission of High Duty Alloys Ltd.

ACHESON COLLOIDS LTD. (Subsidiary of Acheson Industries (Europe) Ltd.) · PRINCE ROCK · PLYMOUTH · DEVON

4 outstanding features of the Lamberton high speed vertical forging press

Caliper type brake
Our own design giving excellent performance under severest conditions.

Top and bottom ejectors
air operated, adjustable to suit all requirements.

Operation of air ejectors
can be limited to every second or third stroke as required.

Calibrated table adjustment
ensures accurate die setting.

The Lamberton Press produces accurate forgings at high speed under rigorous production conditions, and requires minimum maintenance for safe, reliable operation.

Write for details to:—

EUMUCO (England) Ltd

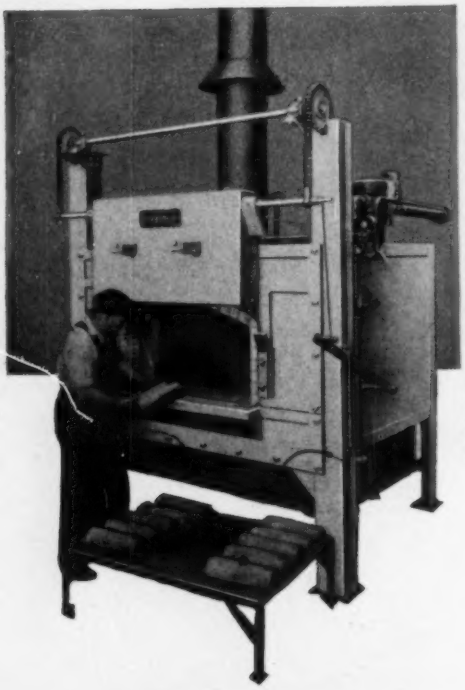
26 FITZROY SQUARE, LONDON, W.1. TELEPHONE: EUSTON 4651

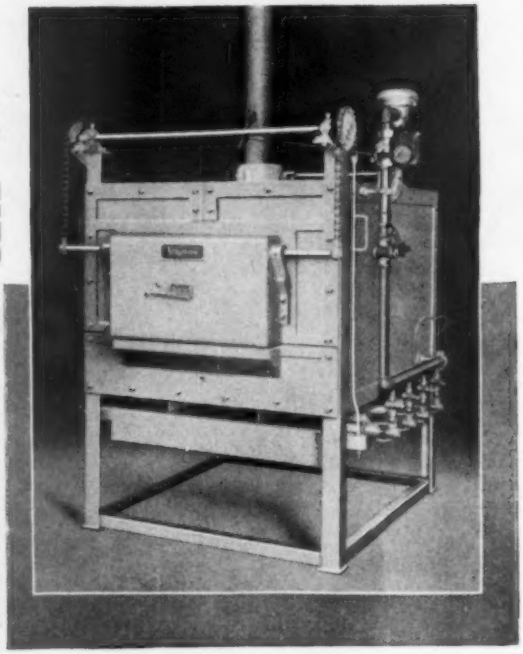
Smee's

Introducing the NEW...

Brayshaw

HYNOR GAS HEATED FURNACE





The Brayshaw Hynor marks a new development in gas fired furnace design and fulfils requirements for a wide range and highly efficient general heat treatment furnace.

Designed for simplicity of operation with pre-set adjustments for easy control the Brayshaw Hynor Oven heated by natural draught burners is available in a wide range of standard sizes for the temperature ranges 650/1,000°C or 650/1,200°C.

For further details ask for a copy of our leaflet A1/58.

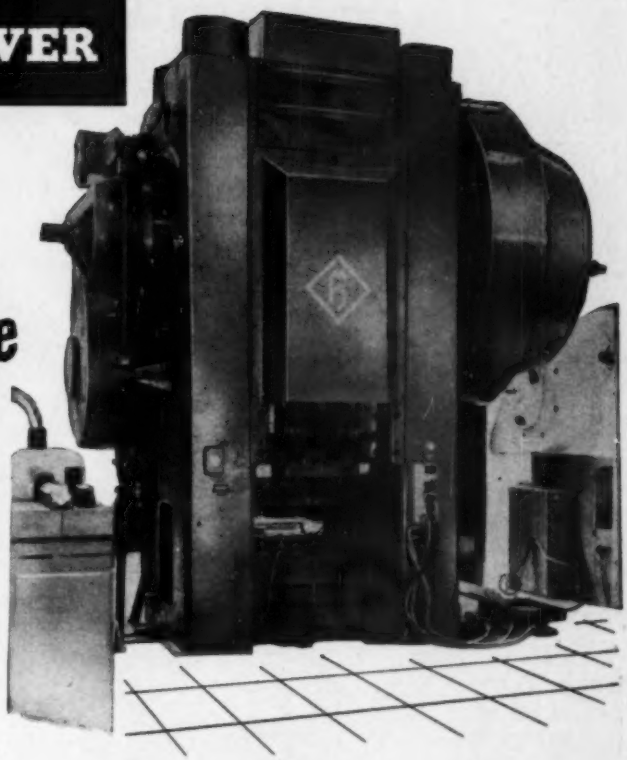
Brayshaw **FURNACES LIMITED**

BELLE VUE WORKS · MANCHESTER 12

Telegrams: HARDENING · *Telephone:* EASt 1046

2,500 TON HASENCLEVER

Eccentric Type Forging Presses



One of three Hasenclever forging presses, producing precision forged heavy bevel gears in a modern car factory. **100 to 6,000 tons.**

By courtesy of FORD MOTOR CO., COLOGNE, GERMANY

PAUL GRANBY & CO. LTD.

39 VICTORIA STREET · WESTMINSTER · LONDON · S W 1

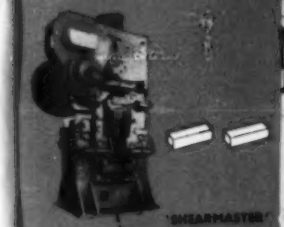
Telephone: ABBEY 5338 Telegrams: POWAFORGE, SOWEST, LONDON Cables: POWAFORGE, LONDON

NRP 1748

Brosius
manipulator
150 Brosius Manipulators now in use throughout the world carry out all the manipulation necessary during forging, saving manpower and time.
The smallest Manipulator will handle pieces up to 2,000 lb. in weight. A wide range of designs are available, the maximum being suitable for pieces up to 20,000 lb. in weight.
THE HEAD WRIGHTSON MACHINE CO LTD
COMMERCIAL STREET · MIDDLESBROUGH
LONDON · JOHANNESBURG · TORONTO · SYDNEY · CALCUTTA
P.X359

FORGING RANGE

WILKINS & MITCHELL



'SHEARMASTER' BILLET SHEAR

'ROLLMASTER' FORGING ROLLS

'FORGEMASTER' HIGH SPEED FORGING PRESS

PPING AND NG PRESS

600 ton capacity Stripping and Setting Presses in the Works of Messrs. Clydesdale Stamping Co. Ltd., Nethertion.

Wilkins & Mitchell Forgemaster High Speed Forging Press, 1,500 tons capacity, and Clipping and Setting Press in production on precision forgings for Messrs. Garringtons, Bromsgrove.

Wilkins & Mitchell Stripping and Setting Presses make multiple operations in line-flow production a practical proposition. This increases the productive capacity of both drop hammer and forging press and ensures:

- increased output
- closer tolerance forgings
- reduced component cost

WILKINS & MITCHELL LTD

DARLASTON · SOUTH STAFFS · ENGLAND

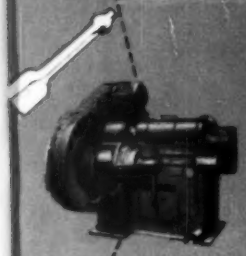
Export Section: 70, Park Lane, London, W.1.

Brosius
manipulator
150 Brosius Manipulators now in use throughout the world carry out all the manipulation necessary during forging, saving manpower and time.
The smallest Manipulator will handle pieces up to 2,000 lb. in weight. A wide range of designs are available, the maximum being suitable for pieces up to 20,000 lb. in weight.
THE HEAD WRIGHTSON MACHINE CO LTD
COMMERCIAL STREET · MIDDLESBROUGH
LONDON · JOHANNESBURG · TORONTO · SYDNEY · CALCUTTA

FORGING RANGE

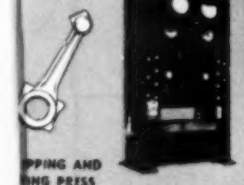
WILKINS & MITCHELL

'SHEARMASTER' BILLET SHEAR

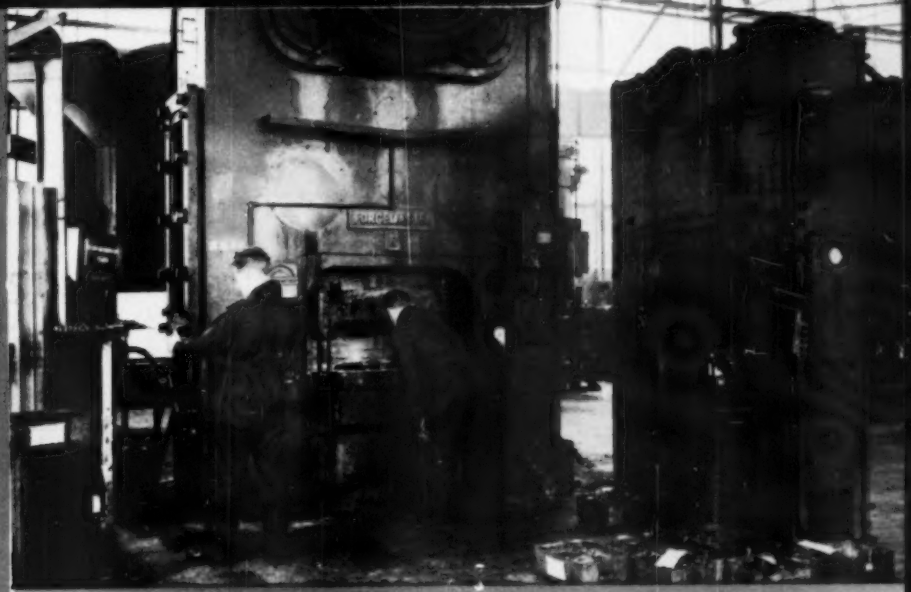


'ROLLMASTER' FORGING ROLLS

'FORGEMASTER' HIGH SPEED FORGING PRESS



PPING AND NG PRESS



600 ton capacity Stripping and Setting Presses in the Works of Messrs. Clydesdale Stamping Co. Ltd., Nether-ton.

Wilkins & Mitchell Forgemaster High Speed Forging Press, 1,500 tons capacity, and Clipping and Setting Press in production on precision forgings for Messrs. Garringtons, Bromsgrove.

Wilkins & Mitchell Stripping and Setting Presses make multiple operations in line-flow production a practical proposition. This increases the productive capacity of both drop hammer and forging press and ensures:

- increased output
- closer tolerance forgings
- reduced component cost

WILKINS & MITCHELL LTD

DARLASTON · SOUTH STAFFS · ENGLAND

Export Section: 70, Park Lane, London, W.1.

"NEWSTAD"

Recirculation Furnaces

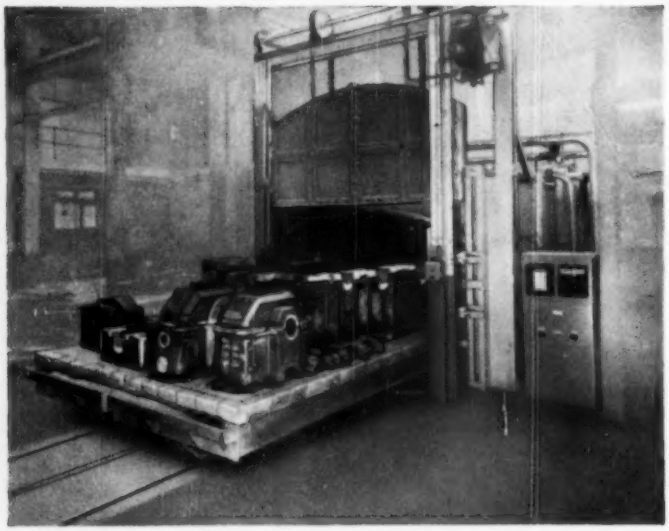


Illustration shows one of our furnaces at Messrs. David Brown Industries Ltd., used to heat-treat fabrications for their famous Radicon gear boxes.

The rapid development of heavy fabrications to replace castings has led to the introduction of our Recirculation Furnaces for stress relieving and preheating. If required these furnaces can be supplied to cover the whole temperature range of 500° to 1100°C.

SEND FOR LEAFLET NO. 47

MODERN FURNACES and STOVES LIMITED

Builders of INDUSTRIAL FURNACES

BOOTH STREET, BIRMINGHAM 21. phone: SMEthwick 1591-2 grams: Mofustolim, B'ham 21

Wild-Barfield A.H.F. equipment is used by Bowden Engineering Ltd. for brazing hose unions. Many other industrial concerns have found that Wild-Barfield A.H.F. induction heating speeds production, saves space and offers savings all along the line. Our engineers will be glad to supply further details and explain how Wild-Barfield A.H.F. equipment can help you.

WILD-BARFIELD A.H.F.

equipment at

BOWDEN ENGINEERING LTD.

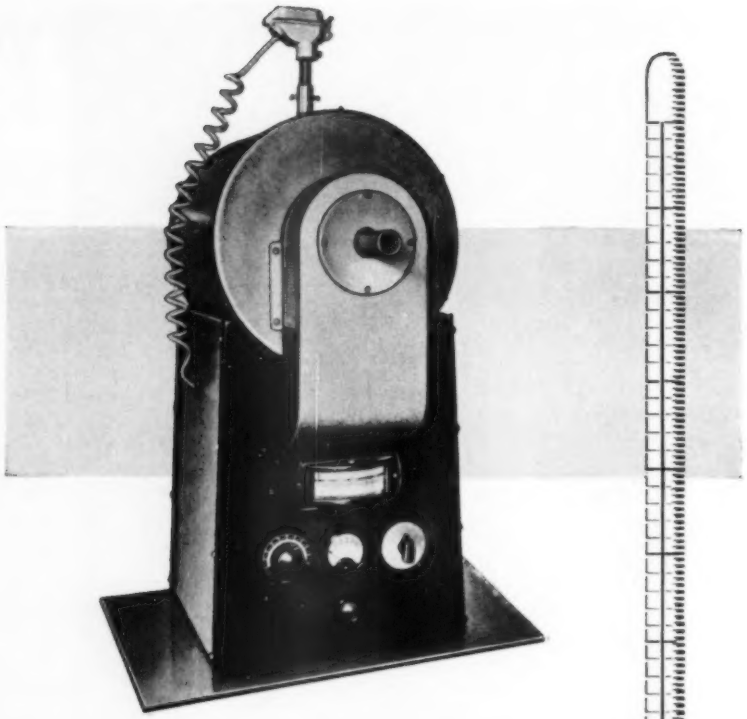
WILD BARFIELD A.H.F.

Induction heating speeds production

WILD-BARFIELD ELECTRIC FURNACES LIMITED

ELECFURN WORKS, OTTERSPOOL WAY, WATFORD BY-PASS, WATFORD, HERTS.

Telephone: Watford 6091 (8 lines)
WB 63



have you temperature investigation problems?

A new Furnace with
360° Radiant Heat Element
Maximum Temperature 1500°C
Effective Heating Length 12"
Diameter of Working Tube 1.092"

The Silit Tube Furnace Type ST.40/3 is a laboratory furnace suitable for tests and heat treatment at high temperatures. This Furnace is of compact design with instrumentation and control equipment housed in the Furnace bench mounting stand.

FOR FURTHER DETAILS, WRITE FOR LEAFLET

Siemens-Schuckert (Great Britain) Ltd

FARADAY WORKS · GREAT WEST ROAD · BRENTFORD · MIDDX
Tel: EALING 1171-6 Grams: Siemensdyn, Brentford, Hounslow
BIRMINGHAM: Tel: Midland 2082 MANCHESTER: Tel: Chorlton 1467 CARDIFF
NEWCASTLE: Tel: 28617 GLASGOW: Tel: Central 2635 SHEFFIELD: Tel: 61564

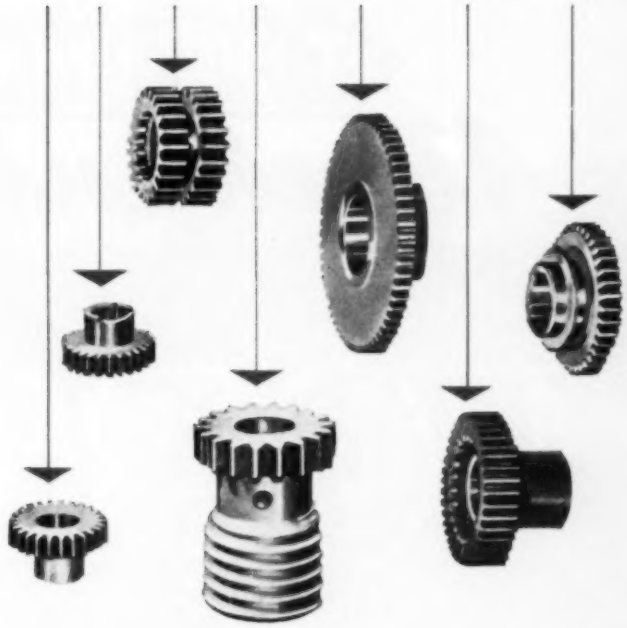
Smee's S.84

The problem

set by

H. W. WARD & CO. LTD.

To carburise and harden lathe gears, which require a high standard of hardness and shock resistance with minimum distortion and a smooth clean finish.



the answer

given by the 'Cassel' Heat Treatment Service

Carburise in 'Cassel' 'Rapideep'; refine and harden from a 'Cassel' C.S.700 bath. The work is conveniently batch-handled in 'Cassel' Salt Bath Furnaces.

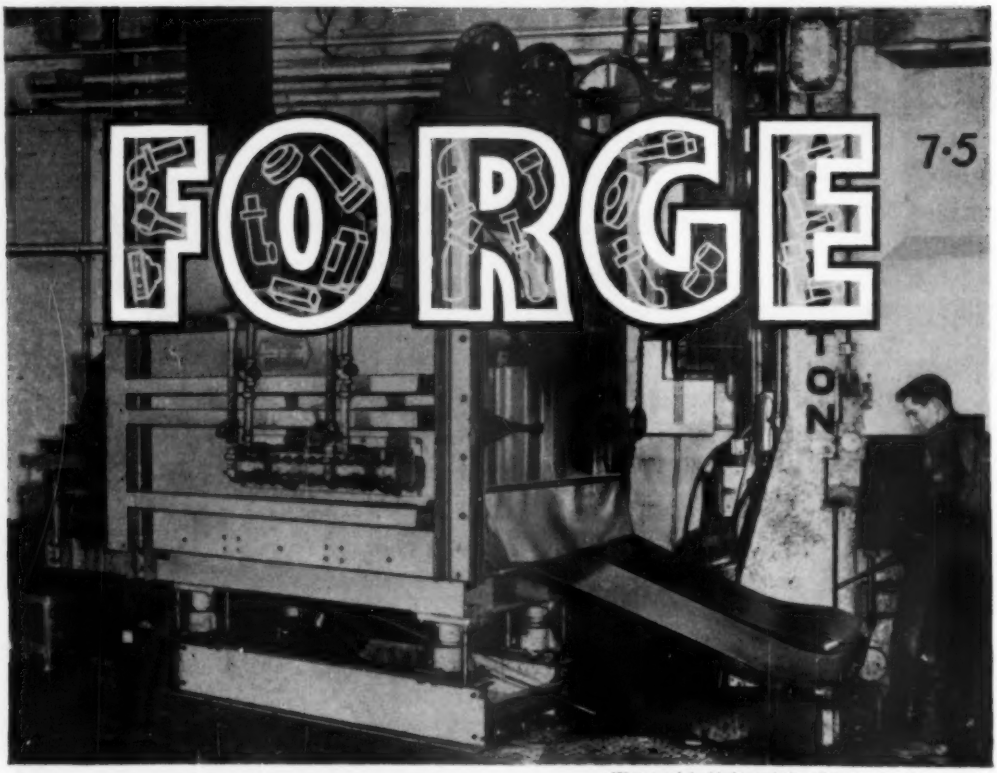
The Heat Treatment Shop—H. W. Ward & Co. Ltd., Worcester

ICI

IMPERIAL CHEMICAL INDUSTRIES LIMITED, LONDON, S.W.1

CC191

THERMIC
Mechanised



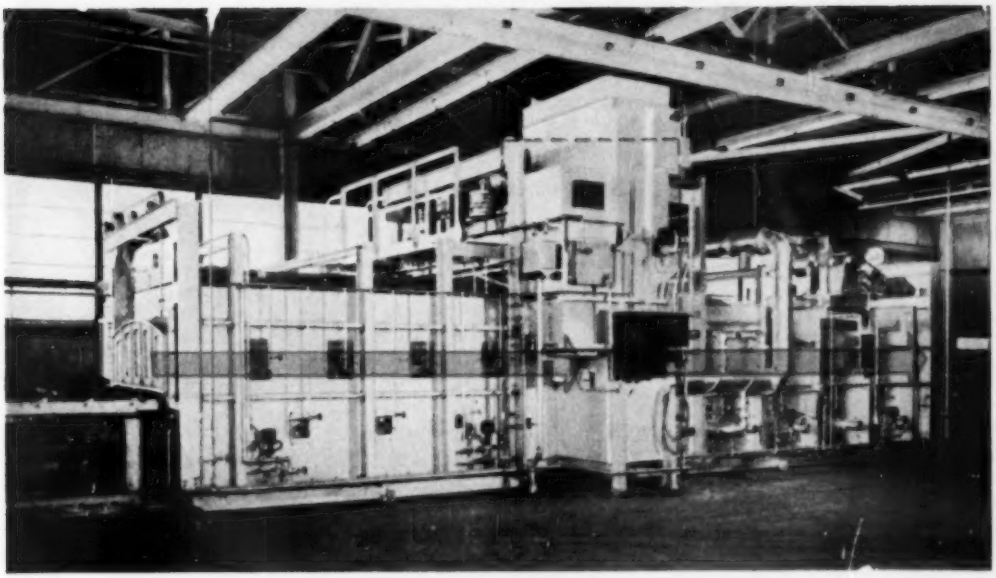
(Photograph by kind permission of the Austin Motor Co. Ltd.)

FURNACES

A wide range of standard or tailor-made mechanised forge furnaces is available, Pusher Type - Rotary Hearth Type - Conveyorised Bar End Heating, with GGC scale-free heating system or fired by gas or oil. The photograph above illustrates a small Thermic Magazine Feed Pusher furnace fired by CC Burners. Output: 7-cwts. of small billets per hour.

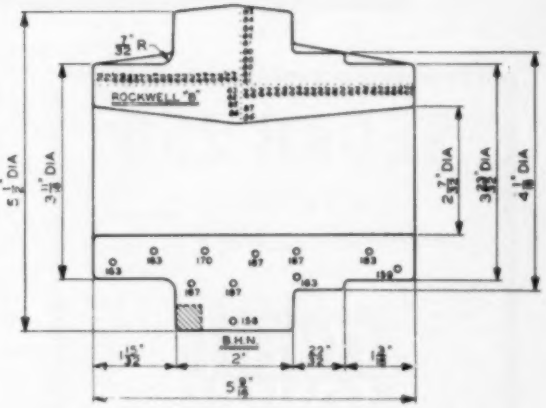
Thermic Equipment & Engineering Co. Ltd.
(Subsidiary Company of Gibbons Bros. Limited, Dudley)
SALMON STREET, PRESTON · TELEPHONE: PRESTON 56254/5 TELEGRAMS: THERMIC-PRESTON

Superfast cooling for cycle annealing



A furnace-within-a-furnace makes this cycle annealer one of the most versatile heat treat units in the country. It anneals, cycle anneals, and normalizes gear forgings of different size, shape, and alloy at the net rate of 1,250 lbs. per hour, or better.

Such exceptional versatility is achieved by a superfast cooling zone. Really a full convection furnace within a direct-fired furnace, this zone is isolated by refractory doors. It can be used or by-passed, depending on which of many cycles the customer wants. As a result, the customer can heat treat as many as 13 different alloys in this one furnace.



Adding to the flexibility of the furnace is a modular tray design. Each module is an 18×20-inch chrome alloy casting. Modules can be combined to hold any size of work up to 800 pounds. They are also used to carry work outside the furnace.

BRITISH FURNACES LTD. CHESTERFIELD
ASSOCIATED WITH SURFACE COMBUSTION CORP, TOLEDO, USA

WHITE CALCIUM-ALUMINATE CEMENT

(Over 70% Al_2O_3)

IRON COMPOUNDS & SILICA LESS THAN 1%

SECAR

250

Registered Trade Mark

This cement when mixed with appropriate aggregates provides Super-duty Castable Refractory Concrete for service temperature up to 1,800 C (3,300 F). Refractory Concrete free from Iron Compounds and Silica is now possible for the first time.

A REFRACTORY CONCRETE FOR ANY PURPOSE

SECAR 250

is a product of

Lafarge Aluminous Cement Co. Ltd.

Manufacturers of

CIMENT FONDU

Reed Trade Mark

ALUMINOUS CEMENT

BECAUSE

Almost the entire Refractory field can be covered by Refractory Concretes based on SECAR 250 or CIMENT FONDU

SECAR 250 concretes have all the well known properties of Ciment Fondu concretes

PLUS

- **HIGH PURITY**
- **HIGH REFRACTORINESS**
- **HIGH SLAG RESISTANCE**
- **HIGH COLD STRENGTH**
- **HIGH SPALLING RESISTANCE**
- **HIGH CASTING ACCURACY**
- **HIGH RESISTANCE TO CORROSIVE ATMOSPHERES**
- **NO SPECIAL PRE-FIRING PROCEDURE**

WRITE FOR BOOKLETS 'SECAR 250' AND 'REFRACTORY' CONCRETE

LAFARGE ALUMINOUS CEMENT CO. LTD. 73, BROOK STREET, LONDON, W.1. TEL.: MAYfair 8846

AP/48

Ask
PRIEST
A Priest Furnace
is the last word
in furnace design
PRIEST
We specialise in the design and construction of:-
Open Hearth Furnaces
Soaking Pits
Furnaces for Aluminium Melting, Coil Annealing and Slab Re-heating
Stress Relieving Furnaces
Forge and Heat Treatment Furnaces
Shipyard Plate and Bar Furnaces
Mould Drying Stoves
Modern Lime Burning Kilns
PRIEST FURNACES LIMITED · LONGLANDS · MIDDLESBROUGH
also at: TELEGRAPH BUILDINGS, HIGH STREET, SHEFFIELD
F122

MANCHESTER FURNACES

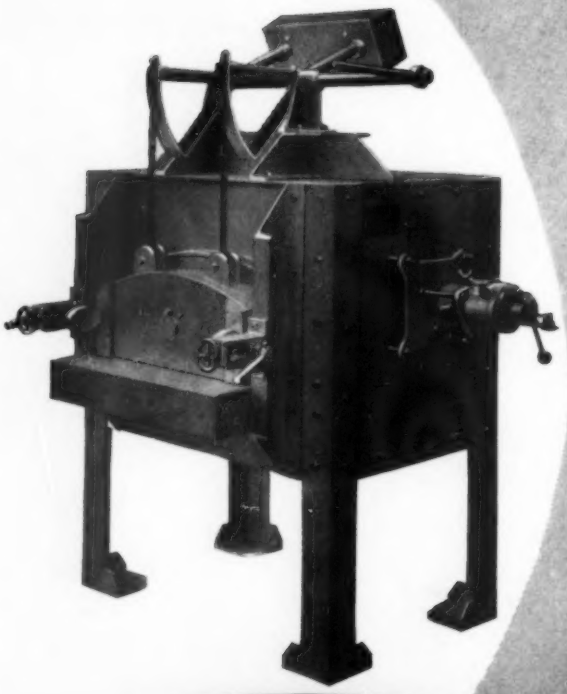
Illustrated is a highly successful batch-type Forge or General-purpose Smithy Furnace. Fitted with Self-proportioning Burner Equipment having *single* lever control of *both* air and fuel supplies, for either Gas or Oil Firing.

●

Built to dimensions best suited to meet purchaser's individual requirements with single door as illustrated, with multi-doors, or double-ended.

●

Highest grade lining and hearth construction with correctly applied burner equipment ensures lowest possible operating and maintenance costs.

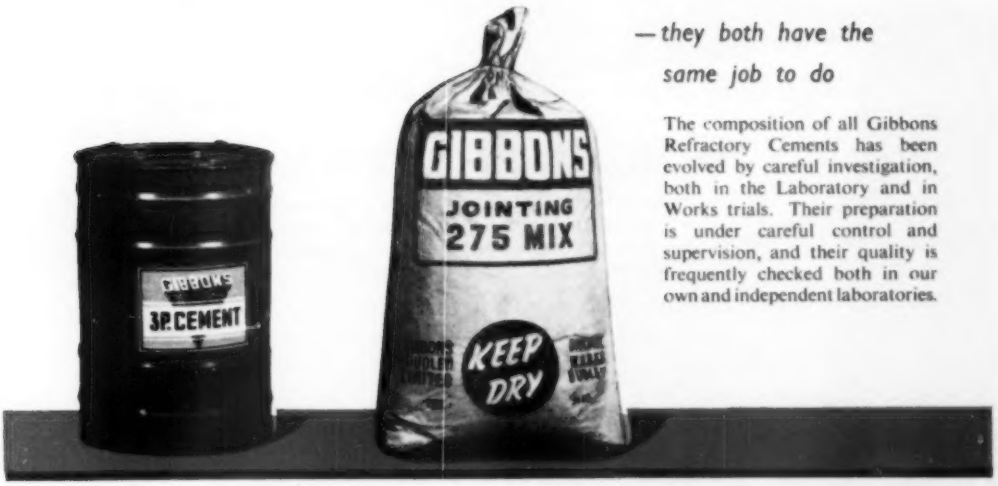


MANCHESTER FURNACES LTD.

Telephone MANCHESTER EAST 0137

GLOBE WORKS • MANCHESTER • 11

Choose your Refractory Cements as carefully as you choose your bricks



— they both have the same job to do

The composition of all Gibbons Refractory Cements has been evolved by careful investigation, both in the Laboratory and in Works trials. Their preparation is under careful control and supervision, and their quality is frequently checked both in our own and independent laboratories.

GIBBONS

REFRACTORY CEMENTS

Refractory and Insulating Refractory Concretes · Firebrick and Insulating Firebrick Aggregates

Gibbons (Dudley) Ltd., Dibdale Works, Dudley, Worcs.

M-W.139

Industry takes

its heat treatment

problems to G.E.C.

DO YOU WANT TO . . .

. . . carburise or carbonitride gear wheels? . . . vitreous-enamel cooker parts?
. . . bright-anneal ferrous or non-ferrous metals? . . . harden high speed steels?
. . . heat billets for extrusion? . . . malleablise cast iron?
. . . braze components in vacuum? . . . normalise metal strip?

WHATEVER YOUR ANSWER . . .

G.E.C. supply equipment for *any* heat treatment process involving metal, plastics or other material. G.E.C. equipment ranges from small portable units to complete installations of a most elaborate type. Installations, specially designed for particular requirements include atmosphere and temperature control and automatic handling gear.

❋ The new G.E.C. Process Heating Data Book — a handy reference to equipment and technical data — is now available. Only 5/- post-free from the Process Heating Dept. Send for your copy now.

for efficient process heating use G.E.C.

FURNACES · HIGH FREQUENCY · INFRA-RED

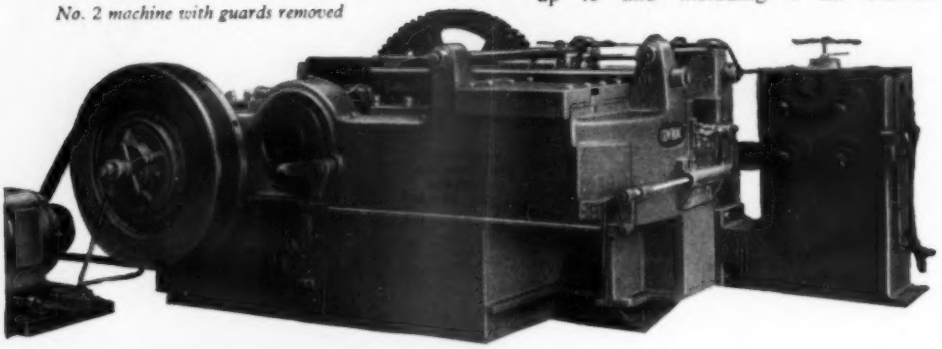
THE GENERAL ELECTRIC COMPANY LIMITED · MAGNET HOUSE · KINGSWAY · LONDON · WC2

SDF
Smethwick Drop Forgings
...FITTED FOR GOOD!
SMETHWICK DROP FORGINGS LTD. • SMETHWICK AND KIDDERMINSTER • ENGLAND

COVMAC AUTOMATIC FORGER

The stock is placed between the rolls and is then fed through the dies to the workstop. The die then closes, cutting off the stock to the required length, and delivers it to the heading position. The heading tool then completes the forging, which falls down the chute on to conveyor. Supplied in several sizes and for making balls of up to and including 4 in. diameter.

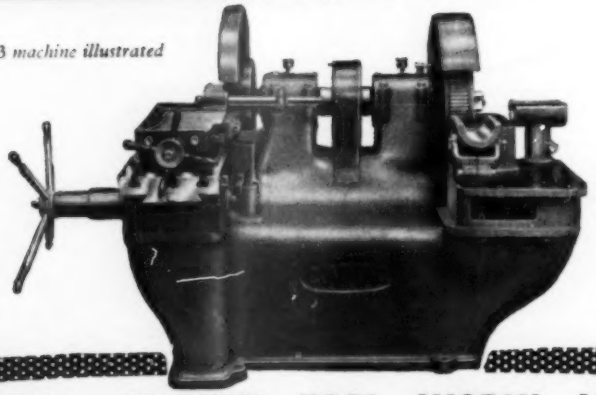
No. 2 machine with guards removed



COVMAC HOT MILLER

These machines are made in three sizes. The smallest handles bars up to 2 in. diameter. The largest size, as illustrated, takes bars up to 4 in. diameter. They are an invaluable asset to any forging or drop stamping plant.

No. 3 machine illustrated



We also make eight sizes of Standard Upsetting Machines to take bars from 1 in. to 6 in. diameter.

COVENTRY MACHINE TOOL WORKS LIMITED

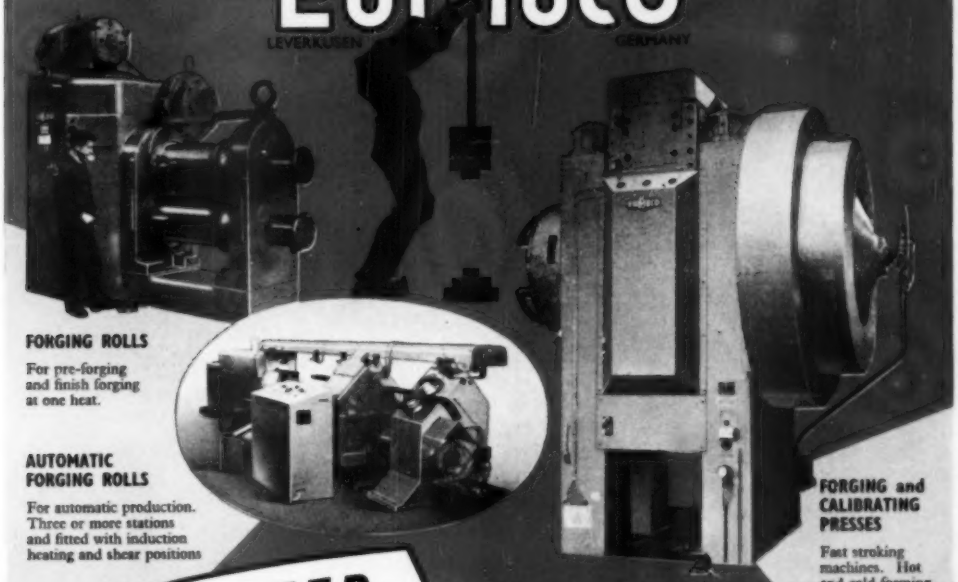
GRANTHAM ROAD, HALIFAX, YORKSHIRE

Telephone: Halifax 3234-5 Telegrams: Covmac Halifax

OVERSEAS AGENTS.—AUSTRALIA: Gilbert Lodge & Co., Ltd., 386 Harris Street, Ultimo, Sydney, N.S.W. CANADA: Williams & Wilson Ltd., 544 Inspector Street, Montreal. FRANCE: Societe Anonyme Alfred Herbert, 1 and 3 Rue du Delta, Paris (90). HOLLAND: Esmeijer & Co., Oosterkade 24, Rotterdam, C. INDIA: Alfred Herbert (India) Ltd., 13/3 Strand Road, P.O.B. 681, Calcutta, 1. NEW ZEALAND: Gilbert Lodge & Co., Ltd., Head Office: 24 Great South Road, Newmarket, Auckland, N.Z. (P.O.B. 9194, Newmarket), also at Christchurch and Wellington. PAKISTAN: Guest, Keen & Nettlefolds in Pakistan Ltd., P.O.B. 819, Bank of India Buildings (3rd Floor), Bunder Road, Karachi. SOUTH AFRICA AND RHODESIA: Hubert Davies & Co., Ltd., Hudaco House, 7 Rissik Street, Johannesburg. SPAIN: Gumuzio S.A., Gran Via 48, Apartado 920, Bilbao. KENYA, UGANDA, TANGANYIKA & ZANZIBAR: Len Cooper Ltd., P.O.B. 3796, Nairobi, Kenya.

EUMUCO

LEVERKUSEN GERMANY



FORGING ROLLS

For pre-forging and finish forging at one heat.

AUTOMATIC FORGING ROLLS

For automatic production. Three or more stations and fitted with induction heating and shear positions

FORGING and CALIBRATING PRESSES

Fast stroking machines. Hot and cold forming with high accuracy.

For FASTER– BETTER FORGING

CHAIN-LIFT DROP HAMMERS

Automatic operation with electronic programme control.

HORIZONTAL FORGING and UPSETTING MACHINES

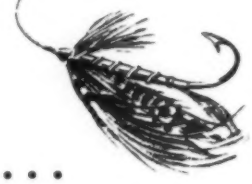
With gripping and automatic bar feed for high speed working.

WICKMAN LIMITED

FACTORED MACHINE TOOL DIVISION, FLETCHAMSTEAD HIGHWAY, COVENTRY

Telephone: Coventry 74321

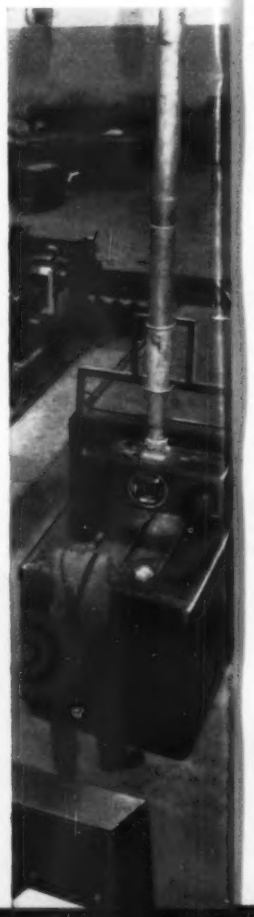
526 F 67/30



the one that got away...

Friday fish, to find one of the few anglers whose hooks are not hardened in Birlec furnaces! For all small steel parts needing accurate production hardening and tempering, Birlec shaker hearth furnaces are pre-eminently suitable.

BIRLEC SHAKER HEARTH furnaces are available in standardised capacities with appropriate non-scaling, non-decarburising atmosphere control.



BIRLEC

BIRLEC LIMITED

An A.E.I. Company

ERDINGTON · BIRMINGHAM 24

LONDON · SHEFFIELD · GLASGOW · NEWCASTLE-ON-TYNE

November 1958

Vol 25, No 158

Metal treatment

and Drop Forging

Editor D. J. O. BRANDT B Sc, A R S M, F I M
Assistant Editor F. D. GRIMMER
Advertisement Manager J. M. DICKIE
Production Manager R. J. LOVELL
Publisher H. J. DWYER
Scottish Area Manager T. H. SMITH

Official organ of the NATIONAL ASSOCIATION OF DROP FORGERS AND STAMPERS

President J. H. SWAIN
Director A. L. STUART TODD, M A, J P

Grove Hill House, 245 Grove Lane
Handsworth, Birmingham 20
Telephone NORthern 3311-3
Telegrams Asdroforge, Birmingham

Published on the 15th of each month by

INDUSTRIAL NEWSPAPERS LIMITED

John Adam House
17-19 John Adam Street
Adelphi, London W C 2
Telephone TRAfalgar 6171 (10 lines)
Telegrams Zacatecas, Rand, London

Subscription Terms Home and Overseas 30s per annum prepayable
Single copies 2s 6d (2s 10d post free)

CONTENTS

This journal is devoted to metals—ferrous and non-ferrous—their manufacture, properties, heat treatment, manipulation, testing and protection, with research work and development in all these fields

441 **A sound move**

443 **The future of mineral exploration**
ANTON GRAY, Ph D, M I M M
The Fourth Sir Julius Wernher Memorial Lecture, in which some problems of the future world supplies of basic metals are discussed

448 **An introduction to modern gears**
New Shell-Mex and B P film

449 **New thermo-chemical techniques Part 2: Powder-metallurgical applications** P. GALMICHE, Ingénieur-Docteur
Descriptions are given of various new techniques derived from the ONERA process of bright chromizing, which can be carried out by using the same equipment

455 **Developments in surface hardening**
E. MITCHELL, F I M, A C T (Birm)
A hard surface may be imparted to steel while retaining a tough interior by using either chemical methods or by means of rapid heating and quenching. The different methods were discussed by the author at the heat-treatment lectures given at the Wolverhampton and Staffordshire College of Technology

464 **Plant developments of Henry Wiggin & Co Ltd**
Production of high-temperature alloys at Hereford

467 **Heating for forging**
N A D F S Spring lectures 1958, No 3. A summary of the third of these lectures which are designed primarily for the younger members of the drop-forging industry

471 **A notable new light forging press**
Opening of the light forge of Walter Somers Ltd at Halesowen, near Birmingham

475 **Gas carburizing and case hardenability**
T. W. RUFFLE, F I M
The necessity of increasing knowledge of the basic data of case hardening led the author to report these studies in the hope that further investigation would be stimulated

482 **Books** 483 **News** 486 **People**

For Temperature Measurement and Control

the KH INDICATING CONTROLLER MARK 4

This advanced Indicating Controller incorporates extremely accurate measuring and control sections in a single compact case. It utilises a photo transistor and a moving coil micro-ammeter thus dispensing with the need for thermionic valves. Requiring less than 46 sq. in. of panel space, the unit has a calibrated indicating scale 8 in. long.

A complete range of instruments is available, which meets requirements over a wide field of process control applications, including models with 2-Position, Proportional and 3-Position action. A programme feature can be incorporated.

- **No Thermionic Valves**
- **Automatic Safety features for Plant Protection**
- **Control Sensitivity: better than 0.1% of F.S.D.**
- **Calibrated Accuracy: within 1% of F.S.D.**
- **Overall accuracy in accordance with B.S. 1041/1943**
- **Plug-in unit with automatic location**
- **Panel space required: only 10⅞ in. x 4¼ in.**
- **Competitively priced**

Please write for Kelvin Hughes publications IND. 703, IND. 704 and IND. 705 which cover 2-Position, Proportional and 3-Position instruments respectively and are available on request.

KELVIN HUGHES PYROMETRY INSTRUMENTS
include
Single and Multipoint Temperature Indicators
Portable Pyrometers and Multiline Recorders

KELVIN HUGHES SPECIALISTS IN INDUSTRIAL MEASUREMENT

KELVIN & HUGHES (INDUSTRIAL) LTD. KELVIN HOUSE, WEMBLEY PARK, WEMBLEY, MIDDLESEX · 60-72 KELVIN AVENUE, HILLINGTON, GLASGOW, SW2

A sound move

FOURTEEN months ago, in our leading article of September, 1957, we described in general terms two new developments in the field of extraction and production metallurgy which we considered promised to be every bit as important in the long run as some of the great inventions of a hundred years ago. These were the new zinc-smelting unit at Avonmouth which, for the first time, utilizes a blast furnace for this purpose, and the Stora powder-steel process which may finally show the way to the production of small quantities of steel strip without the need for a steel melting shop and a cogging mill.

Both these inventions show what can be done when teams of men take their coats off and get down to business, not in the laboratory but in the pilot plant, which, though it may be a small unit, is a replica of the real thing and which will suffer from all the problems of a full-scale plant and a good many more besides. But, in conclusion, we asked whether in fact enough encouragement is given nowadays to young men to give their services to work of this sort. All too often, we felt, recognition by University examination boards and the committees of learned societies seemed to be reserved for the man from the research laboratory. The man who has grown up on the shop floor, and who during his time may have introduced numbers of improvements in techniques and production methods, not to mention actual inventive steps which may or may not be patented—this man fails to receive any such award or recognition outside the works gates for his efforts, because no generally recognized degree or diploma, covering work of this nature, as yet exists. It is true that the societies can and do cover some of this gap by the award of medals and prizes, but this is not quite the same thing as the award of a post-graduate degree, which means either a further string of letters after one's name or the changing of one's title from 'Mr ' to ' Dr.'

This unsatisfactory state of affairs has recently received a further underlining by the remarks about post-graduate research made by Sir Andrew McCance to the Institution of Works Managers' annual conference on October 25. Sir Andrew, who is president of the Iron and Steel Federation, chairman of Colvilles Ltd. and chairman of the governors of the Royal College of Science and Technology at Glasgow, said that in his view research had become too much of a fashionable fetish since the end of the war. ' I have come to believe,' he said, ' that extra time spent in research work after a degree has been taken is in many cases a waste of time. Post-graduate students are carrying out work which has been set for them by the professor; they are not asked to think for themselves. They will never do any real research work because their minds do not run that way.'

With these words we heartily concur. Readers of this journal and of our sister publication *Iron and Coal Trades Review* will recognize that here, in perhaps a more respectable garb, is our old friend ' the sacred cow ' receiving a deserved castigation. The gulf that is

continually widening between ' research,' conducted by white-coated men in the quiet and calm of a laboratory, and ' development,' which often means working at all hours of the day and night amid constant interruption and distraction in the works or in the pilot plant, must be closed. One cannot blame a graduate for going in for the former; quite frankly, it is more likely to be the ' soft option '; the disturbing thing is that so many young men are getting the idea that more and more of this type of ' detached ' research is wanted, whereas in point of fact it is the strenuous, difficult and often dirty work which leads to development that is really lacking.

At the twenty-fifth anniversary dinner of the Newport and District Metallurgical Society on October 24 some remarks in a similar strain to Sir Andrew McCance's were made by Mr W. F. Cartwright, the assistant managing director of Steel Co of Wales Ltd. Proposing the toast of the Iron and Steel Institute, Mr Cartwright said that he was rather disturbed by the fact that all the accounts of new steelmaking processes appearing in the Institute's journal were of continental origin and he wondered whether the methods of selection whereby young men were placed in the steel industry in various positions were working properly. Psychologists, said Mr Cartwright, had told him that, while they could assess a man's mathematical ability and his mental and physical dexterity very accurately, they had as yet no way of determining whether or not a man was likely to be creative. ' But these new steelmaking processes are here,' said Mr Cartwright, ' and we have got to get after them ! ' (Similar sentiments have been expressed in this journal; one of our contemporaries saw fit to accuse us of ' mewling ' !)

However, we rejoice to see that at long last steps are being taken which should help to remedy this state of affairs. The National Council for Technological Awards has announced that a new institution is to be established in London, to be known as the College of Technology, which will make an award which is to become the highest in the technological field in this country—the M C T. To qualify as Members of the College of Technology, which will rank with the Ph D degree, candidates will undertake a programme of studies lasting not less than three years. But they will *not* be doing purely academic work and they will *not* lose touch with industry. The crux of the whole thing is this maintenance of contact which should go a long way towards closing the gulf between research and development.

In Germany, whence so much of the new development work in ferrous metallurgy is coming, the rule is that no candidate may sit for his Dr -Ing who has not, since getting his Dipl -Ing, completed at least two years' service in industry; neither may a man be considered for a university professorship who has not done a reasonable amount of industrial work. The new degree of M C T should ensure that the British youngster, doing six months' night shifts in charge of the —— process pilot plant, has the same chance of academic and material reward as the scientist who works in the research laboratory from 9 a m to 5 p m and who, under our present dispensation, has probably never worked anywhere else.

The future of mineral exploration

ANTON GRAY, Ph D, M I M M

All metallurgical operations, be they extraction, refining, mechanical working or heat treatment, depend ultimately on the supply of metalliferous minerals as the primary raw materials. We publish a slightly shortened version of the Fourth Sir Julius Wernher Memorial Lecture given to the Institution of Mining and Metallurgy in September 1958 *by Mr Anton Gray, Ph D, M I M M, Mining Adviser to the UK Atomic Energy Authority, in which some of the problems of the future world supplies of basic metals are discussed. Dr Gray considers that unless new (concealed) ore fields are discovered, using new techniques, the West faces an acute shortage of primary metals before the end of the century*

When Sir Julius Wernher, just under a century ago, looked at the world and into the future, he had a prospect very different from anything we can see now. Backed by the mechanical power of the Industrial Revolution white men were swarming over the two Americas, pushing with somewhat more difficulty into Africa and penetrating into the fringes of the crowded East. In addition to good land, they were finding metal and coal deposits in abundance. No one else knew how to use them, no one else seemed to want them, and, in America at least, no one owned them. There were few restrictions on travel for anyone with the means or courage to go, and currencies backed by gold were convertible anywhere. In the New World mineral deposits belonged to the finders; in the Old, concessions were not difficult to acquire. It was the heyday of the prospector, and how well he did his work is witnessed by the fact that, in spite of all the engineering and geological achievement of this century, practically all the present production of the major metals comes from deposits, or mineral districts, found by him.

An era of industrial expansion must have been obvious to a man of Wernher's ability. He probably expected increasing mineral production and decreasing costs of production, and in this he was correct. The production of copper, lead and zinc increased steadily, but not spectacularly, until the first world war, then with extreme fluctuations, but about the same general upward trend through the second war. What is not so generally realized is that during this time the cost of producing metals, in terms of currencies related to prices of basic commodities, the closest estimate possible of real values, was steadily decreasing. In 1950 the average real cost of producing copper was about half what it was in 1900, and of all the metals in common use at the end of the 19th century only one, quicksilver, commands a real price today greater than it had then. Even in the recent boom, copper and lead only bettered by a little, and zinc did not reach, their values of 58 years ago. Technology and high production more than compensated for lower-grade ores and higher wages.

Metals in the post-war world

Since the last war most of us, excepting a few incurable romantics, have realized that Wernher's world has not only gone, but gone for ever. Trends of production, costs and prices of the major non-ferrous metals seem to point to a fundamental change. Production increased steadily for the best part of a century until just before World War I it amounted annually to about 1 million tons each of copper, lead and zinc. In the boom that followed the war this figure, very roughly, reached 1½ millions. In the last war copper far outstripped the other two, but this effort, with the facilities available, could not be maintained. The important fact is that since the war the production of all three metals has about doubled and plant now exists for maintaining this production. Allowing for the use of scrap metal, consumption of copper and lead at least must have increased more than twofold in this decade. More significant still, real prices have for the first time since records were kept commenced a steady upward climb. Finally, and perhaps most important, real costs have taken an unprecedented sustained upward trend.

What can be expected for the remainder of this century? Are these trends real and permanent or

are they only the aftermath of a destructive war? To me the indications are that they are real and likely to last a long while. In the first place, the population of the world is increasing at an accelerated rate. Also, the next few generations will feel the full effects of the social revolution that has followed the industrial. The payment for time employed rather than work accomplished has been accepted in the 'democratic' world, together with compulsory social security and the redistribution of wealth by government action. These must make for higher costs of labour, which in the final analysis is most of the cost of producing anything. I need hardly mention the increase in taxes on productive business, by which this redistribution is effected. This is all reflected in the increasing purchasing power of great masses of people which raises the demand for more and more goods and this increasing demand is spreading to all the peoples of the world. We have advertised our way of life well, perhaps too well for our own good! Hundreds of millions of people who up to now have taken little part in either the production or consumption of manufactured goods will do both before long. What can happen is proved by developments in Russia during the last 40 years. The people of China are no less intelligent, industrious and ambitious. Indians are learning to put a standard of living ahead of caste, and Africans are learning not only to use but to produce the white man's goods.

Bearing this in mind, I cannot foresee what the consumption of metals will be by the year 2000, but that it will be considerably higher than at present I have no doubt. Increases since 1950 have already exceeded the guesses of the Paley[1] report. The recent rate of increase almost certainly cannot be maintained, but I would not be surprised if the demand for the major metals doubles again before this century is out.

World metal reserves

Reserves to meet these demands vary. There would seem to be no shortage of copper, iron, manganese, chromite, titanium, nor high-grade aluminium ore for the next 50 years. Reserves of lead and zinc appear to be dangerously low, but this is to some extent at least an illusion. Reserves of these metals are notoriously difficult to determine, and the fields usually produce much more and much longer than anyone is willing to predict. Tin ores are reported to be adequate for 25 years at least, and nickel reserves for about the same period. From the nature of the deposits I would suppose the tin to be underestimated, though nickel reserves may be more difficult to increase. The use of some metals, like niobium, is so dependent on technological developments that reserves in relation to time cannot be estimated. This holds good, too, for many of the minor metals like antimony, tungsten and beryllium, which are produced from small and sporadic occurrences. Nor is it possible to estimate uranium reserves, not for technical but political reasons.

Little is known of Russian resources, nor what China might produce. Russia has long exported manganese and platinum, recently zinc, tin and aluminium. She has been a buyer of copper, but not on a large scale. It is quite possible that the Communist countries could be awkward in exporting or threatening to export metals in times of abundant supplies, as recently with tin and aluminium, but there is no evidence that they have any great exportable surplus of the major metals. Moreover, since they have over a thousand million people to industrialize, it is not likely that they can flood our markets with metals.

There are several ways, other than new discoveries, by which the life of our mineral reserves might be lengthened. Transmutation of the metals, the alchemist's dream, is an accomplished fact for the very light and very heavy metals. But unless a metal is desperately needed, as in the case of plutonium, this does not seem to be a probable solution to metal requirements in the foreseeable future. The use of low-grade ores at added cost is practicable, and quite probable, for aluminium and chromite. It would have little effect on supplies of lead and copper or any of the other major non-ferrous metals. We are left with substitutes and the sea.

During the recent period of high prices much was said about substitutes for copper, and aluminium and plastics undoubtedly have replaced the red metal to some extent. For the principal electrical uses, however, there is no adequate substitute except silver. At a price, lead might be dispensed with for use in batteries, but not in petrol. By and large, substitutes seem to be no serious threat to the metal industry. The sea is a greater threat and may some day prove to be the miner's mortal enemy. When chemists solve the problem of extracting metals from the sea, economically, many of our exploration problems will have been solved, but so far only magnesium, potassium and sodium have been recovered in significant quantities.

Taking all these economic, industrial and social factors into account, the probable demand and apparent reserves, my own judgment is that by the end of the 20th century presently known mineral fields will not be able to supply all the world's non-ferrous metal needs; moreover, we cannot rely on substitutes, synthetics nor the resources of the mysterious East. Even if our political problems could be solved and unhampered distribution of the world's mineral supplies assured, our sons and grandsons will certainly have an exploration problem

on their hands. We have to consider how it might be solved and what chance they have of success. The day of the prospector is done. He flourished in a free world, unhampered by passports, currency restrictions and export controls, and was actuated by that now discredited motive, personal gain. But he found probably 99% of the outcrops that exist to be found.

The economic, technical and political problems we face are very different from, though perhaps not much more difficult than, those which Wernher and his contemporaries had to contend with. The greatest difference seems to be this. Eighty years ago there were plenty of people willing to gamble time and money on a long chance of finding a mine. In the aggregate they made a tremendous effort and did it because the prize of success was fabulous wealth. The winners by whose efforts the mines were found did not have to carry the burden of the many losers. But take away the incentive, tax away the profits of success to redistribute the new-found wealth among the failures, and there will be no more of this speculative effort. It will have to be replaced, and if the replacement is charged to the mines developed, as it seems likely, the price of metals will be increased considerably. Add to this the greater cost of exploring for orebodies that do not outcrop, and it is obvious that the mining companies that have replaced the prospector cannot find and develop mineral reserves of the future as cheaply as our present reserves were secured.

At the present time mining companies operate under another and increasing handicap. Land is becoming ever more valuable and closely held. Many instances are known of exploration being prevented by landowners for one reason or another. It may be that States will find it necessary to expropriate mineral rights in order, paradoxically, to free them for exploration. This has been done in some places with no harm to landowners and great benefit to the mining industry and general public. Certainly we can look forward to much greater government concern in, and control of, exploration. This is probably a necessary development and need not be a bad one if the mining industry as a whole is prepared, as a good part of it is already, to co-operate with government departments. We should be learning now that this co-operation is essential; after all, it is our money they are spending.

Techniques of modern geology

So now the geologists and engineers, organized and financed by the mining industry, helped or hindered by government, take up the work where it was left by the prospector. What exactly are these deposits of ore that are being searched for, and what tools are available for the quest?

Ore is rock containing concentrations of certain useful minerals; rare concentrations, otherwise it would not need to be searched for. Because it is rock we turn first to the geologist for help and learn some very interesting facts. In the first place these concentrations of metals may be, and are, found in all kinds of rock, igneous, sedimentary and metamorphic. Some were undoubtedly formed during, and by the processes of, the formation of the rock itself, as the gold and tin in alluvials, the oolitic iron ores in sedimentary formations and the platinum and chromite in igneous rocks. Others, like certain nickel ores and bauxites, are residual. But with the exception of these sedimentary, igneous and residual concentrations, the deposits from which our metals are recovered, veins, mantos, stockworks, porphyry coppers, limestone replacements, copper and uranium in sandstone, contain minerals which were introduced into openings in the rocks long after those rocks were formed. Nearly all geologists agree that the materials of these minerals were carried by, and the minerals deposited in, water. Lindgren[2] has postulated the physical conditions of their formation, and he believed most of the deposition to have taken place within 15,000 ft of the earth's surface. There is general agreement with this and that ore deposition is connected with the flow of warm mineral springs.

Beyond this there is no agreement; there is chaos. Almost every imaginable source has been suggested for both the metals and the water, as well as nearly every conceivable and some inconceivable methods of getting the metals to the places in which we find them. Nevertheless, one theory is dominant today: that the metals and some of the water came from the deeply buried molten rock material called *magma*, which on solidification produced *igneous rock*. Since granitic magmas are commonly supposed to be the particular source of most metals, it is contended that ore deposits should be looked for in association with granites. That is the theory generally offered as a guide to exploration. Let us see how it works.

We have seen in the past few years an intensive exploration campaign for uranium. When it started the home of uranium was thought to be the granites, and deposits were looked for in and around those rocks. Actually, the great bulk of uranium production comes today from sedimentary rocks in South and Central Africa, Canada and the western United States, where the deposits have no known or even reasonably probable connection with granite. A few uranium-bearing veins, with negligible output, may be genetically related to a known granite.

The great lead and zinc deposits of the Mississippi Valley, Silesia, West Germany, North Africa and Northern Rhodesia are not only in sedimentary rocks, but in some of these fields there is not a granite exposed for miles around. Few lead-zinc replacements in limestone have any apparent con-

nection with igneous rocks, except that their emplacement seems often to have been structurally controlled by dikes and sills. The porphyry coppers are certainly in or near granite porphyry, but there is much more porphyry that is barren, and little or no evidence in detail to connect the origins of ore and rock. In Central Africa the copper, like the uranium, occurs in deposits that have no connection with any known granite. There are no granites that can be pointed to as a source for the Witwatersrand gold.

There are, however, some metals that fit better into the magmatic pattern. Gold veins often, tin, tungsten and beryllium nearly always, occur in or near granite masses. It is obvious that some ore deposits may be magmatic, and a magmatic theory of ore formation can explain and could guide us to them. It cannot, however, explain and would not serve as a guide to the sources of the greater part of our copper, lead, zinc, gold, silver, or uranium production. We thus fall back in effect on the old miner's dictum: 'Gold is where you find it.' Geology has in recent years made great and valuable contributions to our knowledge of the rocks of the earth's crust. It has furnished the oil industry with reliable guides for exploration, but it has not yet done the same for the metal industries. Nevertheless, I am hopeful that it will do so in time to be of use in the intensive exploration effort that I believe will take place in the next couple of generations. In any event, we must see what other tools may be available.

Geophysical methods

Fortunately, there are geophysical and geochemical techniques as well as aids such as aerial photography and diamond drills. There are instruments capable of measuring the electrical conductivity of bodies of rock in the earth's crust or the magnetic and radioactive properties of minerals. Structural problems can sometimes be solved by the measurement of the densities of rocks or the speed with which they transmit shock waves. There are accurate methods of determining the quantities of some trace elements in rocks, soil and water. If these properties or characteristics can be correctly interpreted, if they are used with judgment and discretion, with a complete and objective integrity of thought that is not always easy to attain, they may be of great assistance in locating ore deposits. They are not, any of them, magical divining rods. The diviner's rod, like the philosopher's stone, just does not exist.

The methods of exploration that depend on determining the electrical qualities of an orebody suffer from several serious defects. In practice they are limited to shallow depths, and many orebodies do not yield any abnormal electrical response. Moreover, many bodies of rock or underground water may produce electrical effects without being in any way associated with ore. Carried out over large areas of unknown geology these surveys give results so indeterminate as to be practically useless. Nevertheless, although they will not by themselves find the metals we need, these surveys are useful for tracing and finding extensions of known orebodies. I expect that a good part of the ore reserves I believe to occur in known mineral fields will be located in this way.

For ores that are magnetic the magnetometer has proved extremely useful, but few non-ferrous metal deposits respond significantly to it. Instruments for detecting radioactivity have recently become familiar to all, and their usefulness is obvious; but they will not in practice discriminate between radium, thorium and potassium, will not pick up radiation from a mineral buried under a few feet of earth and, if flown systematically over large areas, are apt to show up a multitude of anomalies that are practically meaningless in any search for ore. Like the electrical methods, magnetometer and radioactivity surveys will probably have their greatest application in tracing extensions of known deposits.

Recently, electromagnetic instruments operated from an aeroplane have been developed. Of all the geophysical 'pointers' this seems to have the best chance of success in large-scale exploration. It suffers from most of the inherent defects of the other electrical methods, but it can cover large areas quickly, and there is a possibility that its discrimination will be improved. If this can be done it will probably be one of the best methods of prospecting for sulphide deposits under shallow cover, such as over-burden or glacial till.

On the whole, it would seem that we can look to these direct geophysical methods for only auxiliary help. We cannot survey a large unknown territory with any one of them and hope directly to locate orebodies. At best, we get indications of places that deserve closer study on the ground—first to confirm an anomaly, then to drill to see what causes it. Such work has been successful in finding ore. A great deal of money has been fruitlessly spent on geophysical surveys, but, used in carefully selected areas and interpreted by men of ability and experience, they can continue to have successes. Instruments and methods will improve, but the inherent disabilities will remain, and in inexpert hands these techniques will continue to squander money, and worse, because they can give the impression of having condemned ground that deserves thorough prospecting.

Geochemical surveying

The only other direct pointers to the metal deposits are the so-called geochemical surveys. In plain terms, this means simply the accurate deter-

mination of the elements, and particularly minute quantities of the metals, in the rocks, soil, water or vegetation accessible for sampling. When a mineral deposit decomposes at the surface it must leave some trace of its former existence in the soil that overlies it. When that soil or its soluble metal content is washed down the streams into the vallevs the metallic traces enter the drainage system. Following them back to the deposit in place is simply doing what prospectors for gold have done since Jason stole the Golden Fleece. The new factor is the development of chemical techniques which enable the determination, not of colours of gold in a pan, but of minute quantities of zinc or some other metal in soil or water; and to make many determinations cheaply and quickly. There is no doubt that the soil in its trace elements carries the history of the rocks from which it was formed, and that ground waters similarly carry the record of the rocks they have passed through. If we could read and interpret that record we would know pretty well what exists in the upper crust of the earth, and our exploration problems would be a long way towards a solution. It will not be as simple as panning for gold, and I expect no sudden easy solution to the problems of prospecting. I do expect that the gradual accumulation of geochemical knowledge will prove to be the most important factor in the direction and success of exploration in the near future.

Bear in mind that over the greater part of all the continents the solid rocks are buried beneath soil, swamps or glacial deposits. Moreover, many of the older rocks are covered by younger sediments and lavas. As mineralized outcrops remaining to be investigated become fewer and fewer, a successful search for mineral deposits becomes ever more dependent on the ability to predict, beneath the surface deposits, the presence of the structures that may contain orebodies. It is well known that the search for oil has been guided with phenomenal success by seismic surveys and that the Far West Rand was located by one of the ablest applications of a magnetic survey.[3] But the seismic survey itself locates no oil and the Rand survey pointed to no ore. Such surveys simply help to solve the problems of the structure of rocks. If enough is known about the structural environment of the substance being searched for, the survey furnishes information on which to locate drills, and the rocks can be tested to see if in fact they do contain the concentration being sought. And this brings us to the heart of the exploration problem. For the discovery of oil we have an almost adequate knowledge; for mineral deposits we have not. We have come full circle and are back to Agricola. It is more than ever necessary that the miner ' must understand the veins, stringers and seams in the rocks.' He must, but as yet he does not.

Unsolved problems

I believe that the problems of ore deposition have not been solved primarily because the need for a solution has not been urgent. Metal requirements have been met so far by the development and expansion of mineral fields located by means of outcrops; and it is quite possible to make an estimate of what may be the total yield of these known fields, making full allowance for probable hidden orebodies. But in considering future exploration we are not concerned with the discovery of a new orebody in the Copperbelt. Such discoveries have been discounted in our estimate of reserves. We are concerned with the discovery of a new copperbelt and because such fields probably always betray themselves somewhere by outcrop, unless the mineralized rock is covered by some younger formation, it follows that new fields will most probably be found only under such younger rock. We must learn somehow to know, or to predict the existence of, mineralized structures when under not jungle and glacial deposits, but, more important still, the lavas and sediments that cover the flanks of the younger mountain chains.

I believe that developments in the knowledge of how rocks are formed, particularly of how they are altered and metamorphosed, coupled with the ability to date geological events that have been furnished by recent studies of radioactivity, may in the near future give the geologist and the miner the understanding necessary to do this. We cannot continue to maintain, after the studies of men like Read[4] on granites and Turner and Verhoogen[5] on metamorphism, that the ore-forming processes are exclusively either igneous or sedimentary—they may be neither.

On the basis of world supply and demand alone, either new reserves of metals must be found before the end of this century or great shortages will develop. It seems obvious that the conditions, economic, political and social, in which this exploration must be carried out will be vastly different from those in which our present reserves were built up. Yesterday men like Wernher put their personal resources into exploration in the hope of winning prizes they expected to keep. Today Communism rules in half the world, exploration is a matter of State policy and mineral production a weapon to be used in the economic warfare between East and West. Even in the West all countries have to some extent placed socialistic controls on the mineral industries, the prizes are increasingly difficult to retain and private funds for exploration more difficult to find. When a corporation now spends money on exploration, the taxpayer, not the shareholder, pays most of the bill. Tomorrow the intense nationalism of today

continued on page 448

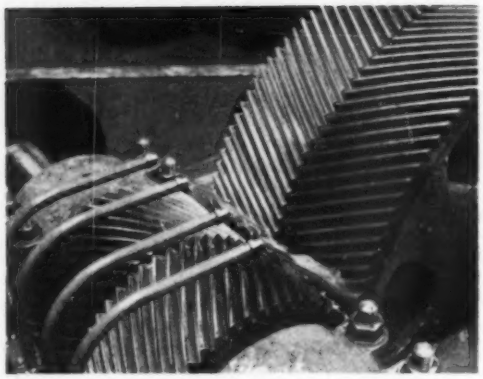
'An introduction to modern gears'

'AN INTRODUCTION TO MODERN GEARS,' the new Shell-Mex and B P film, will, it is believed, fill a need since there is no other general film on gear manufacture in existence. The technical advice of Dr H. E. Merritt, internationally known for his work on gear designs, makes it an authoritative film in its field. The Merritt-Brown gearbox, which he invented, was widely used in British tanks in the late war. A number of leading manufacturing companies assisted with technical advice and readily granted facilities for filming. This is the first film to show the research work done at PAMETRADA, which includes sound analysis from tape recordings of transmission noises, and the use made of the photo-elastic technique in research.

The film was planned as a training aid for schools, technical institutes and individual industrial concerns operating their own schemes for training apprentices.

The special characteristics of rolling friction, the principles of gear design, and the salient features of the main techniques of cutting and generating gear teeth are discussed and illustrated. A special rig clearly demonstrates how gears having involute teeth can be generated from a straight-sided rack, and this principle is demonstrated by rack planing and other forms of gear generation.

Examples of the constant research conducted by the oil industry into all aspects of lubrication are given and to show how operational research stations maintained by large industries anticipate problems



Lubrication of a double helical by spray (from 'An introduction to modern gears)

arising from ever-increasing loads and gear speeds, the film moves to the PAMETRADA marine research establishment on the Tyne, one of whose major tasks is the rigorous testing, under simulated operational conditions, of complete ship's power units for long periods.

The film shows how gear vibrations under load are recorded on a wide-range magnetic tape and also illustrated is the photo-elastic technique, which enables the movements of stresses inside gear teeth under load to be actually seen.

'An introduction to modern gears' was devised by Shell-Mex and B P Ltd and produced by Random Film Productions Ltd. It is available in 35 and 16 mm gauge.

The future of mineral exploration

concluded from page 447

looks very much like developing into nothing short of industrial feudalism, and when metal shortages occur they will be the concern of the State.

What part private industry will play in future exploration depends on political developments in the countries concerned. In any country it will be conditional on the acceptance by industry of the social obligations demanded by the times, and on its ability to convince government and public that it can do for them a better job than they can do for themselves.

Finally, the miner can never expect as simple and sure a guide to ore as the petroleum industry has to its oil reservoirs, for the problems of mineral deposition are too varied and complex. But if more mining geologists will relax their obsession with the theoretical possibilities of hypothetical magmas, and help to solve the structural and chemical problems of metamorphism, we may have in the near future the understanding needed to guide us to ore deposits. Most of the mineral deposits in and around the older mountain chains may have been found because some evidence of them was exposed by erosion. Given the knowledge of how the metals are concentrated during, and by the processes of, metamorphism, it may be possible for us to locate not only deposits that are covered by glacial till and swamps, but also those associated with the younger mountains, the deposits not yet exposed by denudation.

References

(1) 'Resources for freedom,' Report of the President's Materials Policy Commission (Paley Report), U S Government Printing Office, Washington, 1952, 2.

(2) Waldemar Lindgren, 'Mineral deposits,' 4th edition, McGraw-Hill Book Co Inc, New York, 1933.

(3) This refers to the survey conceived by Rudolf Krahmann and instituted by Leopold Reinecke about 1930 for Consolidated Goldfields of South Africa Ltd.

(4) H. H. Read, 'The granite controversy,' Thomas Murby & Co, London, 1957.

(5) F. J. Turner and J. Verhoogen, 'Igneous and metamorphic petrology,' McGraw-Hill Book Co Inc, New York, 1951.

New thermo-chemical techniques

Part 2 Powder-metallurgical applications

P. GALMICHE, Ingénieur-Docteur

In this article, descriptions are given of various new techniques derived from the ONERA process of bright chromizing, which can be carried out by using the same equipment. Part 1, which appeared last month, described the bright annealing of steels and refractory alloys, while Part 2, which concludes this article, deals with different applications of the hot-chromizing process and of reducing atmospheres halogenized 'at equilibrium' in powder metallurgy. Mr Galmiche is with the Office National d'Etudes et de Recherches Aéronautiques (ONERA), France

PROTECTION AGAINST WEAR OF *material used in powder compacting* When chromium diffusion is applied to carburized metals in conditions which enable the avoidance of any decarburization of the surfaces, by heating of the parts in granulated chromium with the addition of a little ammonium fluoride, and in certain cases of an inert diluent, the result is the production of very smooth surfaces, stainless as well as very hard with a base of chromium carbides. The hard chromized surfaces thus formed have excellent sliding characteristics and so ensure very good protection against wear and abrasion, either cold or at high temperature. The coefficient of friction of chromized surfaces can be still further improved by a short electrolytic polish in Jacquet baths with perchloric acid, acetic acid or, in some cases, by annealing in fluorized atmosphere.

The steels from which dies and core rods for powder compacting are generally made, carburized chromium steels, are particularly suitable for the hard chromizing treatment, all the more so since the ONERA technique enables the heating conditions suitable for the metals under treatment to be observed, especially as regards speeds of heating and cooling. Annealing, preceding the heat treatment for regeneration of the mechanical properties of the treated workpieces, can be done without risk of decarburization in the ammonia atmosphere used for the protection of the chromizing boxes owing to the great stability of chromium carbides. It is also possible to do the heating in salt baths or, in certain special cases such as self-hardening steels, to do the whole treatment in a closed vessel in the presence of fluorized compounds.

The hardness of the surface layers obtained (about 2,000 Vickers), together with the surface quality obtained from chromium diffusion in fluorized atmosphere (fig 6), results in a considerable increase in service life of the parts. As the addition of chromium takes place without any removal of iron from the parts, the process can be applied for the protection or building-up of worn parts, after mechanical polishing or grinding. It is, moreover, possible in certain cases to make the parts in ordinary carburized steels, the surface layers formed by hard chromizing being, in any case, made up of chromium carbides.

In the same way as for protecting steel used for powder compacting, hard chromizing results in a considerable improvement in the service life of extrusion, cold-drawing and high-temperature dies of many metals or alloys (fig 7), these parts being generally made of carburized chromium-tungsten steel, or sometimes of non-magnetic alloys (18/8).

Protection of sintered iron parts Chromium diffusion is one of the few solutions for effective protection of sintered iron and steels against corrosion both cold and at high temperature. The treatment can, in certain cases, be carried out at the same time as the sintering of parts of iron, nickel or alloy powders, the temperatures and lengths of the two operations being suitable for this.

The quality of protection of ferrous parts is essentially linked with the initial porosity of the treated parts. It is particularly high when the treated parts have a low porosity, as the addition of chromium completes the sealing up of the pores.

When the protection given by this treatment is

too low because of the excessive porosity of the parts in the first place, it is possible to improve the resistance to corrosion of the chromized parts by selective oxidation of the surface zones rich in chromium. The oxidizing treatment is most frequently done by heating the parts in ordinary electrolytic hydrogen, which always contains traces of oxygen. The chromized surfaces fix the oxygen by progressive sealing-up, whilst the iron inside the parts remains unaffected owing to the low stability of iron oxide in the presence of hydrogen.

Protection of dynamically-free metal powders The problem of obtaining iron powders dynamically free and coated with diffusion layers of perfectly regular thickness and with a predetermined chromium content arises in the case where such powders are to be used as energy transmission agents between movable magnetic plates. It is known that, in these conditions, the temperature of the particle surfaces can reach periodic temperatures of the order of 700° C.

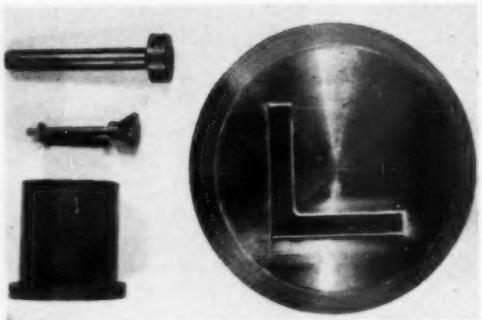
A special technique for doing this simply has been developed,[4] in which the added chromium, added in a very fine form or set up *in situ*, is completely used up during the operation carried out at about 950° C, without it being possible for the iron particles to agglomerate (fig 8). It is thus possible to get precise and reproducible results. The iron powders treated in such an operation show a magnetic permeability almost equal to that of pure iron powder. They are not remanent and resist oxidation up to about 700—750° C. The maximum temperature for using coated powders can be raised either by carrying out a controlled oxidation of the metal after chromizing, or by applying mixed cementation (Cr-Al or Cr-Zr).

When the treated powders or granules are carburized, this results in very hard surface layers being produced, which allow of the materials being used as abrasives.

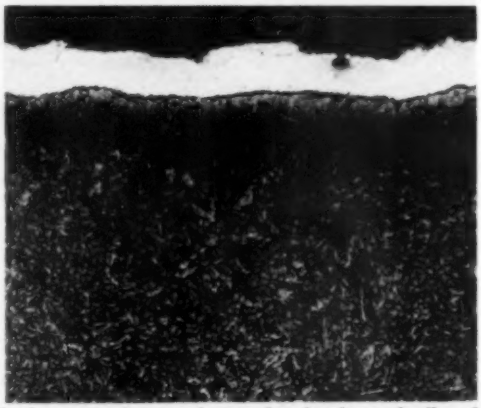
The treatment can also be applied in a similar way to powders or fibres of various metals or alloys which can be cemented by chromium (13% Cr magnetic alloy, nickel, cobalt, molybdenum, etc).

It is also possible to obtain ductile powders of chromium alloys, completely free, by increasing the temperature or the length of the operation (iron-chrome; iron-chrome-aluminium; nickel-chrome). These powders can be subsequently sintered or chromized-sintered.

Sintering of chromium-bearing metal powders[5] Sintering of alloy powders with high chromium contents is difficult owing to the thin skin of oxides which is present or tends to form on the particle surfaces during the operation. Accordingly, sintering of such powders is usually done in pure hydrogen.

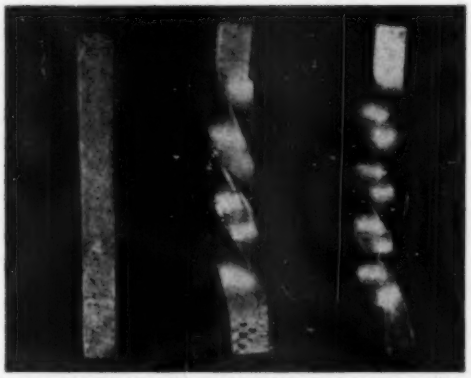


6 *Pressing and extruding parts, treated by hard chromizing*

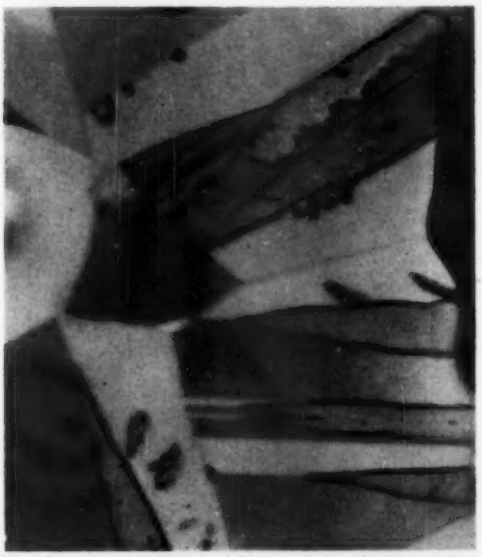


7 *Structure, after use of part, of surface layer of collar of steel-extrusion die, hard chromized. Etched hyposulphite-bisulphite*

8 *'Densified' chromized iron powder. Etched bitric alcohol. × 500. Note penetration of chrome along the grain boundaries, assuring protection in case of breakage*



9 *Samples of 18/8 alloy sintered in fluorized atmosphere and twisted to show ductility of material*



10 *Structure of 18/8 stainless steel powder sintered in fluorized atmosphere for 1 h at 1,150° C. Absence of any precipitation at grain boundaries has necessitated a special metallographical etch (hydrochloric-hydrofluoric in alcohol. × 200)*

When the compressed powders, placed in a sheath of chromium or supported by an inert diluent, are heated in a reducing atmosphere halogenized at equilibrium similar to those used for bright annealing or chromizing annealing, a quantitative elimination of the chromium oxide skin takes place from the beginning of the operation, even if the treatment boxes are heated in non-purified reducing atmospheres. The operation leads, moreover, to the decarburization and purification of the powders under treatment, which results in high-density products being obtained after sintering, these being relatively very ductile and perfectly homogeneous in structure; this is all the more marked as the use of halogenized atmospheres in the treatment gives rise to a considerable activation of the sintering owing to the movement of metal in the gaseous phase (figs 9 and 10). The use of fluorized reducing atmospheres in treatment in equilibrium can be generalized for activating sintering of various metals and alloys of which the halogenides are not very volatile and are reducible by hydrogen.

When the sintering treatment in fluorized atmosphere is carried out, not on the chromium alloy powders, but on the powders of the constituent elements of these alloys, the chromium is brought to the particle surfaces of the base metal by ' internal gaseous chromizing,' which improves still more the quality of the sintering and makes the operation cheaper owing to the use of basic products which are less costly than the alloy powders.

Plastic chromium powder and dense machinable sintered products[6] Chromium is usually considered to be a hard, brittle metal, from which it is not possible to make articles by machining. Also, sintering of chromium powder is difficult because of the great sensitivity of chromium to oxidation. This operation has to be carried out usually at temperatures of the order of 1,400—1,500° C in purified hydrogen so as to ensure the production of very cohesive parts free from oxide.

Compacted parts obtained from electrolytic chromium powder, the most usual form in which the pure metal is supplied, are highly porous and very brittle. It is in any case essential to add a binding lubricant to the powder before pressing.[7]

11 *Compressibility, as a function of pressure applied, of fine treated electrolytic chromium powder and of original powder (15 g samples : pressures ranging from 1—6 t/cm²)*

These various drawbacks have, up to now, prevented chromium parts being used, although this metal has the considerable advantage of having a high melting point (1,900°C), together with good heat conductivity and of being inoxidizable up to about 1,100°C.

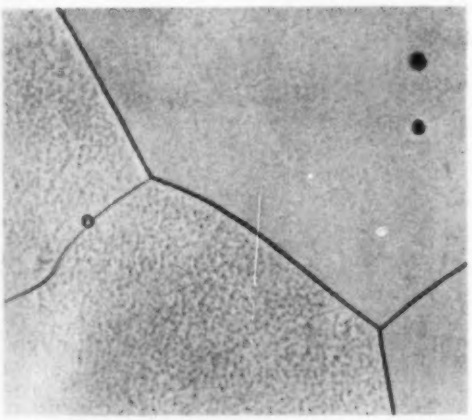
It has been established that the brittleness of chromium is due to the presence of impurities very difficult to avoid or remove (oxygen, nitrogen). Various authorities have recently succeeded in obtaining specimens of ductile chromium, in particular by purification of electrolytic chromium specially prepared and heated to a high temperature (1,200—1,400°C) in perfectly pure hydrogen.[8, 9] Others have made use of the reduction of very pure chromium chloride[10] or the dissociation of the iodide.[11]

In the process developed by ONERA,[12] purification of the chromium is effected on the powder without any agglomeration of the granules, in a simple way and at a relatively low temperature (about 1,100°C), by the action, under specific conditions, of reducing atmospheres halogenized at equilibrium, notably bromized atmospheres. The process allows of the treatment, without limit of quantity, of the powder in conditions easy to obtain. The protective atmosphere of the treatment boxes is most frequently of ordinary electrolytic hydrogen.

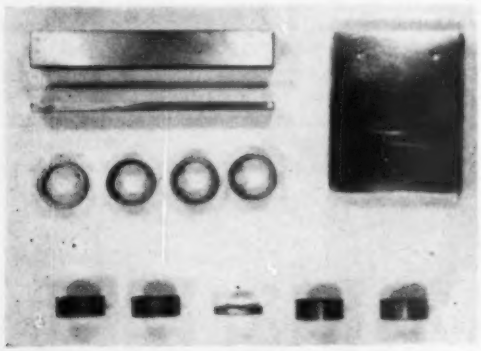
As purification of the powder is for a great part linked with the diffusion of impurities towards the particle surfaces, from whence they are removed, the treatment is particularly applicable to fine electrolytic chromium powder or magneso thermic chromium powder produced direct by the ONERA HIVERT-TACVORIAN process.

Chromium powder submitted to the action of atmospheres halogenized at equilibrium in the ONERA technique is quantitatively de-oxidized at the beginning of the operation, even if additions of chromium oxide have been made (*e g* to improve later decarburization). Metallic impurities of chrome are also eliminated (silicon, aluminium) in the form of volatile halogenides, and also sulphur in the form of sulphuretted hydrogen. The chromium particles, however, remain practically unattacked owing to the high boiling points of chromium halogenides and to their instability under treatment conditions. The same thing occurs in the treatment of powders of chromium alloys, *e g* 18/8, 25/10 and Nimonic powders.

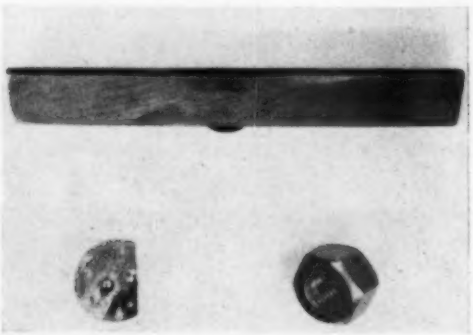
The fine powder of electrolytic or magnesothermic chrome, refined by the halogenizing treatment, has a totally different appearance and compactibility from the original powder with its initial dark-grey colour. The treated powder is of a clear silvery grey colour and its cold compactibility



13 *Structure of ductile chromium powder sintered at* 1,700°C *after pressing at* 5 *t/cm². Etched anodic soda.* × 2,000

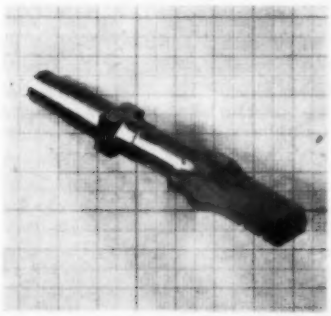


12 *Various components made by pressing from ductile chromium powder*

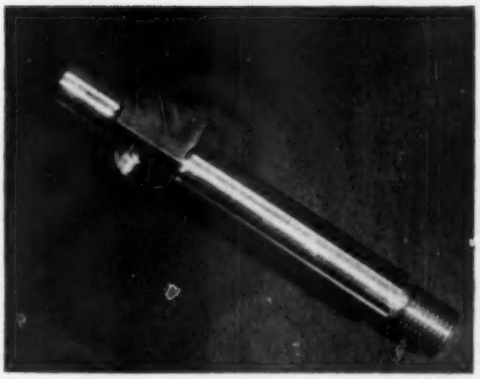


14 *Various samples machined from ductile chromium powder, sintered at* 1,150°C. *Cold pressed at* 5 *t/cm². Note hardness reading impressions on cylindrical specimen.*

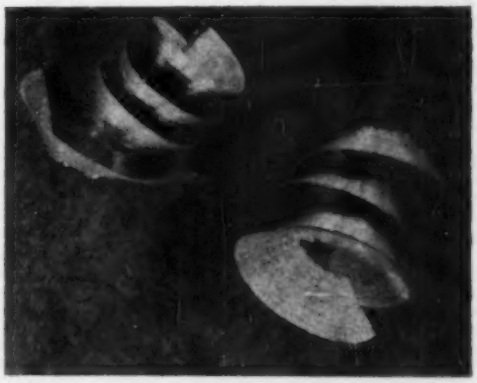
characteristics, as a function of the pressure applied, are similar to those of iron powder (fig 11). Pressing can be done either cold or hot without risk of sticking, using the same standard equipment, even if no binder has been added to the powder as a lubricant. The pressed powder has a bright appearance, is of high density and not brittle[14] however complex the components made from it may be, and it is possible to produce from it thin plates or flat rings (fig 12). Sintering of ductile chromium powder can be done at a fairly low temperature, without shrinkage or internal oxidation (parts are bright white when sintering is done in fluorized atmosphere). The products obtained have a very high mechanical resistance cold or hot, 9 kg/mm² (6 tons/sq in.) with cold-bend tests of 28 kg, and 31 kg/mm² (18 tons and 20 tons/sq in.) on samples originally pressed at 5 t/cm², sintering being done at 600°C, 875°C and 1,130°C respectively. The hardness of the material obtained is not high in spite of low porosity (60—90 Brinell-Vickers) for samples sintered between 875°C and 1,700°C. The material has a very homogeneous structure (fig 13), is only slightly brittle cold and is very ductile at high temperature. It can be calibrated, re-repressed cold or hot after pre-sintering, forged or even rolled at not too high a temperature. Re-pressing of samples, pre-sintered, followed by a further sintering or annealing, allows of products being obtained of which the density is near to the theoretical density of chromium and of which the mechanical characteristics are changed. Thus, re-pressing of samples pre-sintered at low temperature enables products to be obtained with a very high density and with a hardness which can exceed 200 Vickers on samples re-pressed cold under a load of 6 t/cm². This hardness decreases progressively as a function of the annealing temperature and becomes stable after 1,000°C, at values of about 100 Vickers. Microscopic examination shows evidence of recrystallization of the material.



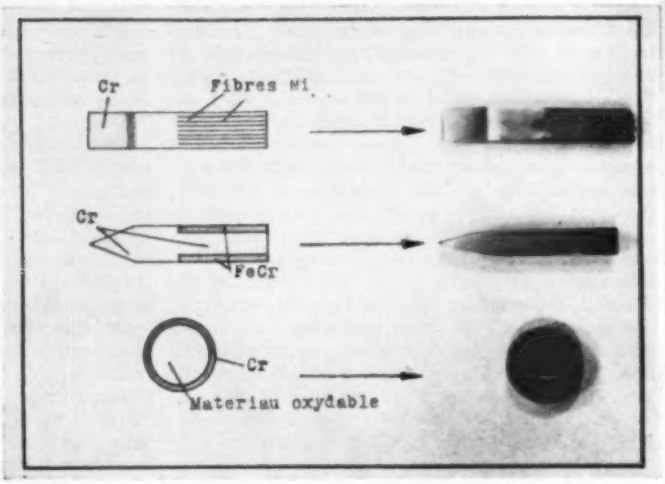
Materials so obtained by sintering can be machined cold like steel (figs 14 to 17). In the case of parts to be made from re-pressed blocks, machining can be done either direct on the products re-pressed cold or hot, or on blocks annealed after pressing. Finish-machined parts can also be given a further annealing or sintering. When articles in sintered chrome are porous owing to low initial compaction, it is possible to seal up the pores by impregnation in a fluorized atmosphere or by controlled oxidation of the surface zones. This last operation is done by gradual heating up in air or in damp electrolytic hydrogen and results in the formation of a very hard surface layer with a melting



15 and 16 *Parts machined from block of ductile chromium powder, pressure 5 t/cm². Pre-sintered at 900°C and re-pressed (density 6·84). Sintered after machining at 1,150°C*



17 *Chromium turnings produced from machining parts*



18 *Types of composite parts made from ductile chromium powder.*
TOP *Chromium reinforced with nickel fibres (etched with hydrochloric acid)*
MIDDLE *Chromium with part sleeve in ferro-chrome (body of chromium powder and of sleeve of iron powder plus chromium powder sintered together)*
BOTTOM *Part of combustible material sheathed with ductile chromium*

point higher than that of chromium, which can also play the role of heat protection.

In addition to the production of articles in pure chromium, such as fuse parts, sheaths for heating or burning elements, rods for welding or scooping, the use of ductile chromium powder has already been envisaged for making, by sintering, both alloys with a chromium base (Cr-Mo-Fe: Cr-Mo-U) and also composite materials in which chromium, in association with compounds such as certain oxides, plays the part of an inoxidizable ductile constituent. It is also possible to obtain by sintering at not too high a temperature, starting with ductile chromium powder, which does not shrink during sintering, complex articles such as objects in chromium reinforced with fibres of different metals or alloys (Fe: Ni: Mo: W, etc), or also composite sintered articles of which only a portion is made from chromium powder (fig 18). The ONERA treatment of chromium powder can finally be used for purifying the metal which is utilized for preparing, by the usual methods, refractory alloys or certain light alloys.

References

(4) ONERA: B F 1,147,786—14/3/56, etc . . . .
(5) ONERA: B F 1,060,225—11/7/52 and addition 56,880 of 26/3/56 etc . . . .
(6) Article to be published in *Recherche Aéronautique*, 1958.
(7) Sully, 'Chromium.' Butterworths Scientific Publications, London, 1954.
(8) R. W. Fountain and M. Korchinsky, Haynes Stellite Report, June 11, 1957.
(9) H. Smith and A. Seybolt, *J. Electrochem Soc.*, 1952, **103**, 347.
(10) H. Gilbert, H. Hohansen and R. Nelson, Bureau of Mines Report 4905.
(11) D. Maykuth, W. Klopp, R. Jafee and H. Goodwin, *J. Electrochem. Soc.*, 1955, **102**, 316-331.
(12) ONERA: P V 735,475 of 2/4/57 and 738,524 of 14/5/57.

Liquid metals for heat transfer

The use of liquid metals for heat transfer has been brought to the forefront by nuclear reactor developments, since their high thermal conductivity makes them suitable for applications where very high heat transfer rates are required, as in the fast neutron reactor. Moreover, in sodium and sodium-potassium eutectic alloy particularly, are substances which do not capture neutrons wastefully and are therefore acceptable for reactors.

The use of these substances, stated Prof O. A. Saunders, F R S, in an address before the British Association, in Glasgow, especially where water was likely to be present, seemed at first sight to present formidable practical difficulties, but with the improvements in sealing and handling techniques which were in any case essential in dealing with nuclear appliances, these were no longer considered even serious. Prior to the nuclear application the only liquid metal used was mercury, which had the disadvantage of toxicity. Heat transfer coefficients for liquid metals had now been extensively measured, but there was still some uncertainty in interpreting results that might be connected with the effects of thermal conduction in the direction of flow, which was negligible in non-metallic liquids.

Liquid metals would probably be more widely used for heat transference in many industrial applications in the future, such for example as in steam reheating in power plant, where they would enable the steam to be heated in heat exchangers close to the turbines. It was to be remembered, however, that liquid metals had relatively low specific heats compared with other liquids, which meant that the weight of fluid necessary for a given heat removal might be high. The high temperature-drops across the thickness of the walls of the tubes carrying liquid metal coolant might also become a critical factor, reaching as much as 500°F in 0·02 in. thickness of stainless steel tube wall, for a flux of 3,000,000 B Th U. It seemed that with the coming of new industries such as electronic, aircraft engineering, nuclear and chemical engineering, quite new kinds of heat transfer problems arose, or at any rate unexpected developments of old problems.

Series on heat treatment

Developments in surface hardening

E. MITCHELL, F I M, A C T (Birm)

In this lecture, given to the Wolverhampton and Staffordshire College of Technology, the author considers the fundamental principles of surface treatment of steel parts, which may be carried out either by altering the chemical composition of the surface, or by localized heating and cooling, giving an altered metallurgical structure. Mr Mitchell is heat-treatment and development engineer at Joseph Lucas Ltd

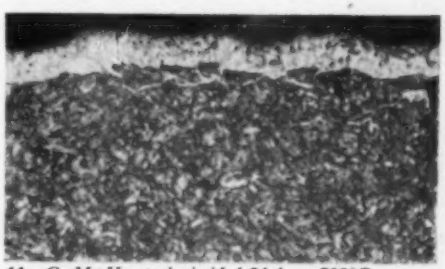
Addition of nitrogen

This is an established method which consists of subjecting machined parts to the action of a nitrogenous medium under certain conditions whereby surface hardness is imparted to the material without any further treatment. Pure ammonia is used as the nitriding medium and this dissociates at elevated temperatures in contact with the hot-steel surface to provide nitrogen. It is necessary in this process to use special steels which are relatively expensive and the normal alloying additions are chromium, vanadium, molybdenum and aluminium.

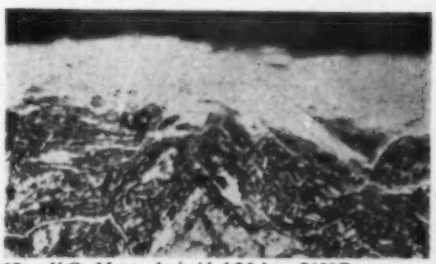
This method is often used where retention of hardness at elevated temperatures and freedom from distortion are important. It is recognized that the poor features of this process are that the steel is expensive, the treatment itself is lengthy, and there is a white layer formed which normally has to be removed before components can be put into service. Recent developments of interest in this respect are concerned with the shortening of the treatment and reducing the amount of white layer. Some new ideas have emerged using two- or three-stage techniques of high and low ammonia dissociation, sometimes with a temperature variation during the nitriding cycle. The first of these is covered by a patent held by C. F. Floe.

The amount of white layer can be reduced by the control of ammonia dissociation and the use of a high temperature not only increases ammonia dissociation but also results in faster penetration rates. This effect is illustrated in figs 11, 12 and 13.

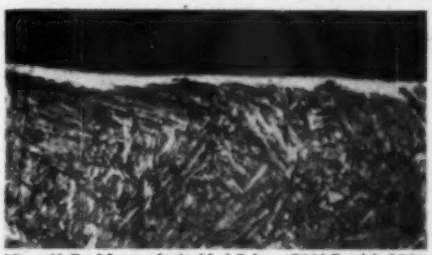
Pressure nitriding Another recent development has been that of pressure nitriding[5] using ammonia at pressures of 200—800 lb/sq in., and claims have been made that this gives faster penetration rates in the early stages of the process and a reduction in the white layer. It is also said that ammonia consumption with this method is reduced by about 90% compared with conventional practice. From the



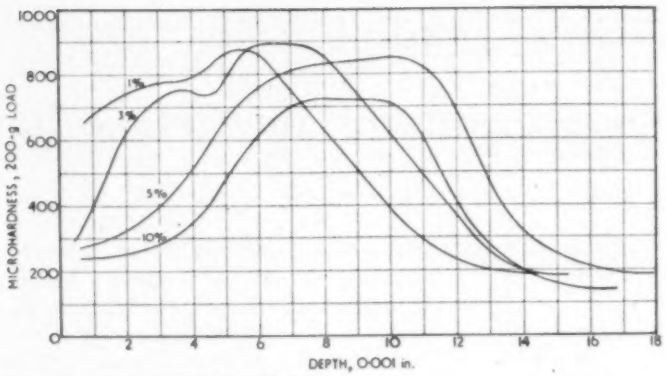
11 *Cr Mo Va steel nitrided 24 h at 500°C 30% ammonia dissociation.* × 500



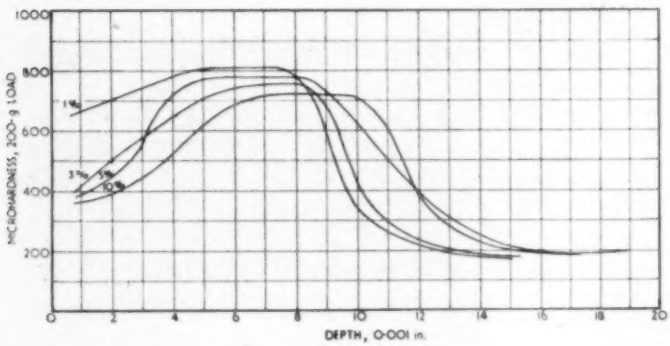
12 *Al Cr Mo steel nitrided 24 h at 560°C 30% ammonia dissociation.* × 500



13 *Al Cr Mo steel nitrided 5 h at 560°C with 30% ammonia dissociation 19 h at 580°C with 60% ammonia dissociation.* × 500



14 *Mild steel treated in raw town's gas at 800°C with various ammonia additions*



15 *Mild steel treated in raw town's gas at 850°C with various ammonia additions*

TABLE IV *Variation of nitrided case with time*

Dimension	Hours at temperature									
	4		15		45		60		90	
	Normalized	Quenched and tempered	Normalized	Quenched and tempered	Normalized	Quenched and tempered	Normalized	Quenched and tempered	Normalized	Quenched and tempered
TYPE 135										
Total case (inches) ..	0·0085	0·0070	0·0095	0·0120	0·0190	0·0200	0·0180	0·0190	0·0212	0·0240
Maximum hardness (v p n)	1,180	1,225	1,225	1,250	1,195	1,215	1,225	1,195	1,185	1,160
Depth over 700 (v p n) ..	0·0032	0·0033	0·0062	0·0067	0·0150	0·0148	0·0163	0·0161	0·0197	0·0195
White layer (inches) ..	0·0003	0·0003	0·0005	0·0007	0·0011	—	0·0004	0·0005	0·0007	0·0005
TYPE N										
Total case (inches) ..	0·0090	0·0055	0·0105	0·0095	0·0185	0·0190	0·0190	0·0160	0·0235	0·0240
Maximum hardness (v p n)	1,035	1,065	1,130	1,130	1,150	1,010	1,150	1,125	1,100	1,100
Depth over 700 (v p n) ..	0·0034	0·0028	0·0064	0·0069	0·0144	0·0128	0·0162	0·0128	0·0196	0·0146
White layer (inches)	0·0002	0·0002	0·0004	0·0006	0·0010	—	0·0003	0·0004	0·0008	0·0005

Temperature, 1,000°F; pressure 800 lb/sq in; 10 g ammonia initially per sq ft exposed area

TYPE N (%)

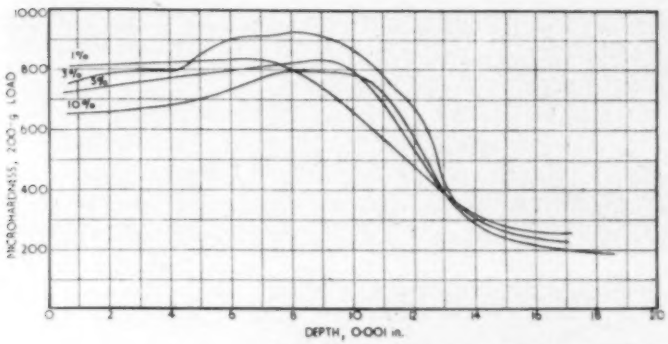
C	0·24	Ni	3·31
Mn	0·56	Cr	1·23
Si	0·29	Mo	0·26
		Al	1·54

TYPE 135 (%)

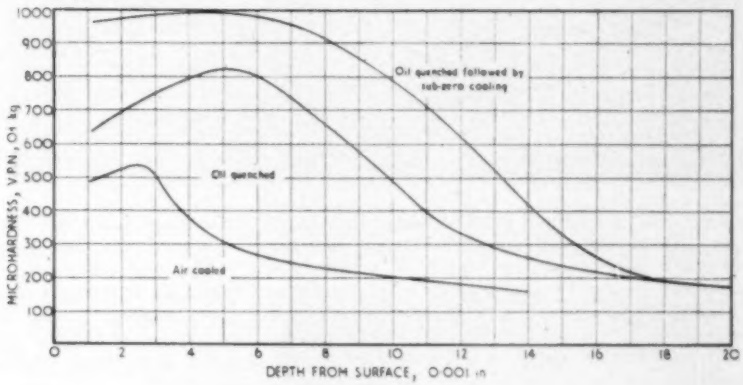
C	0·35	Cr	1·45
Mn	0·46	Mo	0·37
Si	0·18	Al	1·26

published data[5] on normalized and hardened and tempered specimens given in Table IV, it can be seen that a deeper case than with conventional nitriding is obtained at the end of 4 hours; but at 45 hours the depth of penetration is about equal for both methods. It is interesting to note the increase in white layer up to 45 hours' treatment and then the fall off which occurs at 60 and 90 hours. Furthermore, it will be seen that the depth of white layer is less than that normally obtained with conventional nitriding.

Two techniques have been mentioned. In the first a capsule of liquid ammonia is inserted into the parts which are to be nitrided. This technique is



16 *Mild steel treated in rate town's gas at 900°C with various ammonia additions*



17 *Effect of sub-zero treatment on nitrogen-rich carbonitrided case*

TABLE V *Vickers hardness of carbonitrided mild steel (5 kg load)*

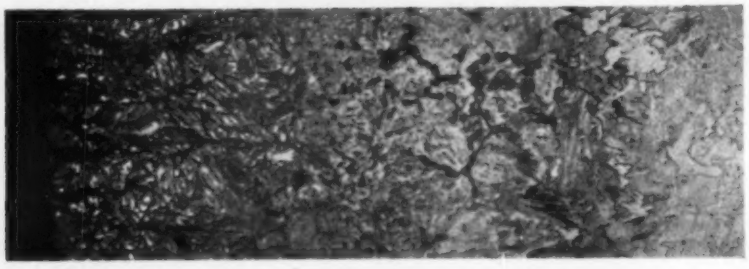
Temperature, °C	Cooling method	% Ammonia in R T G				
		0	1	3	5	10
800	W Q	445 (H)	638 (H)	371 (H)	244 (H)	307 (H)
	O Q	200	546 (H)	321 (H)	418 (H)	423 (H)
	A C	200	524	310 (H)	265 (H)	321 (H)
	F C	152	423	386	187	316
850	W Q	800 (H)	726 (H)	550 (H)	447 (H)	454 (H)
	O Q	441	661 (H)	480 (H)	502 (H)	396 (H)
	A C	234	466	430	416	406 (H)
	F C	193	386	370	362	319
900	W Q	701 (H)	840 (H)	766 (H)	712 (H)	613 (H)
	O Q	690 (H)	810 (H)	660 (H)	726 (H)	644 (H)
	A C	289	381	485	473	312 (H)
	F C	234	325	364	370	239

(H) Indicates file hard

usually used for tubes which are sealed and then placed in a suitable heating unit. As the tubes are heated the seal on the capsule melts and the liquid ammonia vaporizes and fills the tube which is being nitrided. The second system uses ammonia supplied from a cylinder connected to a retort which is placed in the furnace in the usual way. No provision is made for exhausting used ammonia from the retort, and an adequate pressure is built up from the cylinder and then the retort is sealed.

It is well known that only the nascent nitrogen which is formed from the breakdown of ammonia has any active effect in nitriding. As soon as nitrogen atoms combine into molecules, they become

18 *Mild steel treated at 800°C in raw town's gas + 10% NH_3 showing intergranular constituent and austenite.* × 250



19 *Mild steel treated at 900°C in raw town's gas + 1% NH_3—satisfactory structure.* × 250

useless from a nitriding point of view, and it is for this reason that in conventional nitriding an adequate and continuing supply of ammonia is necessary for the chemical reaction at the surface to proceed. Under moderate pressure, however, this ammonia reaction is reversible and the catalytic reaction which does occur in a nitriding box under pressure can be expressed as $2\ N + 3H_2 \rightleftharpoons 2NH_3$. For this reason much less ammonia is needed in a pressurized system since the ammonia is being continually re-used.

'*Ionitriding*' Another new nitriding technique, referred to as 'Ionitriding,' which may well find extensive use is that which utilizes a glow discharge.[6] In this method each part is made to carry an electric potential as a cathode and by means of glow discharge heats separately to a suitable nitriding temperature. Conventional furnace equipment is not used, neither is it necessary to heat up a whole furnace or retort in order to raise a number of components to nitriding temperature.

The normal operating procedure is to place individual parts in contact with electrodes in a metal cylinder which is then sealed and evacuated. Nitrogen and hydrogen are then fed into the container and a high current is supplied to the electrodes. This both heats the parts and produces glow discharge. At this stage the atmosphere is ionized and nitrogen in its atomic form is projected towards the parts and starts to diffuse into the steel surface.

It has been said that atomic nitrogen erodes the surface of the metal during glow discharge and that, in consequence, minute particles are removed. This is not sufficient to affect dimensional tolerances, but it has been noted that these particles, in the form of fine metal dust, collect inside the container.

The main features of this process appear to be that: (1) It is faster than conventional nitriding; (2) it produces less white nitride than the normal method; (3) a tougher case is formed; and (4) less power is wasted by heating up an entire furnace and retort.

Addition of carbon and nitrogen

Methods involving the addition of both carbon and nitrogen have been well publicized in recent years. Perhaps the name used most often to describe such techniques is that of carbo-nitriding, although many others, such as dry cyaniding, gas cyaniding, nicarbing and nitro-carburizing, have been mentioned. These methods have been proclaimed as innovations but it must be remembered that the simultaneous addition of carbon and nitrogen to steel is not new. Cyanide hardening is, in fact, such a process, also many plants were in operation 20 years ago in which skin hardening was carried out with the use of a cracked oil and cylinder ammonia. What is new is the gaseous interpretation of this idea linking the use of the latest atmosphere-generation plant with furnaces which have been designed specially to give adequate gas circulation. Basically the carbon is supplied by means of carbon monoxide or methane and the nitrogen by the cracking of ammonia.

The main advantage of carbonitriding is that the addition of nitrogen lowers the critical range of the steel and it is then possible for carbon to be absorbed at temperatures lower than those normally

used for carburizing. In addition, nitrogen slows the transformation rate of austenite, thus allowing adequate surface hardness to be obtained even with comparatively slow cooling rates. This slowing of the transformation rate is proportional to nitrogen content, and plain carbon steels treated at low temperatures in atmospheres with a high ammonia concentration can be hardened in air. Surface layers formed in this way, however, are very shallow and have a tendency to be brittle and to spall. As the temperature of the process is increased, there is a tendency to absorb more carbon in preference to nitrogen and a surface layer is formed which contains more carbon. When a high ammonia concentration is used, this case will still contain sufficient nitrogen to slow down transformation rates so much that even relatively slow cooling will result in retained austenite and a low skin hardness. This austenite could be transformed by sub-zero treatment but this is obviously not good practice. However, by suitable control of carburizing atmosphere, ammonia addition and temperature it is possible to obtain a surface layer on mild steel which is martensitic on oil quenching. The use of high ammonia concentrations and low temperatures is also to be avoided if the presence of a black intergranular constituent not positively identified but believed to be iron carbonitride, is to be prevented. Figs 14 to 19 and Table V give some idea of the effects produced by varying temperature and ammonia additions with raw town gas as the base of the atmosphere.

The atmospheres used for carbo-nitriding are all based on ammonia additions to carburizing atmospheres which may be: (*a*) Raw town's gas, (*b*) endothermic gas with or without butane, and (*c*) a carburizing gas generated from a liquid hydrocarbon.

The first of these carburizing atmospheres can be used quite satisfactorily for carbo-nitriding but the surface finish is invariably not so clean as that obtained with ammonia additions to (*b*) and (*c*).

Carbo-nitriding lends itself conveniently to automatic furnaces and it is now felt that the rotary drum, sealed quench, and shaker-hearth equipments are the most likely to be used for carbo-nitriding. For small components and case depths up to 0·020 in. it is likely that carbo-nitriding equipment may well take its place in production flow lines.

It is claimed that carbo-nitriding provides a cheap technique for hardening small parts and that a saving of 40—50% can be made over other accepted skin-hardening processes.

Two methods often used where local surface hardening is required are flame hardening and induction hardening. These are employed where the cost of special equipment, which is relatively expensive, is justified either by long runs or by the possibilities of making relatively simple changes to work-heads, burners or inductors. These methods have the well-known advantages of using power only when it is wanted and of being easily mechanized. It is, perhaps, true to say that a number of important features of these processes as now used are taken for granted, but nevertheless these features are the results of fairly recent experience and cannot be over-stressed.

Flame and induction hardening

It is now common to harden both medium-carbon steel and the carburized case of a steel by these methods, and the choice of material is bounded by economics which are often determined by fabrication or machining convenience. The metallurgical requirements of a steel or that portion of the steel, which is to be hardened, are similar whether the method used is flame or induction. It will be reasonably obvious that freedom from de-carburization is essential. It must also be remembered that it is wise to specify steel having a structure of finely dispersed carbide if adequate hardening is to be obtained with the short heating times used in induction heating. Table VI illustrates this point.

20 *Flame hardening—flat burner (Surfard Ltd)*

What is often forgotten, however, is that a fabricating process such as copper brazing or an intermediate treatment such as normalizing may well give a structure with a pronounced ferrite network which requires a much longer soak during the hardening stage.

More attention is now being given to the question of the specification of a steel suitable for flame or induction hardening and it is of interest that in

TABLE VI 0·48%*C steel induction hardened at* 400 *kc/s* (*after Hancock*)

Previous heat-treatment	Surface hardness, D P H	
	0·03 in. case, 0·6 sec heating time	0·06 in. case, 1 sec heating time
Hardened and tempered ..	787	823
Normalized 850°C ..	550	780
Annealed 850°C and slow cooled	530	622

Germany steels with high surface hardness but shallow depth-hardening characteristics are being developed. One such steel has a percentage composition, 0·65—0·75 C, 0·2—0·4 Mn, 0·15—0·3 Si. It is likely that some hardenability test may figure largely in any worthwhile specification.

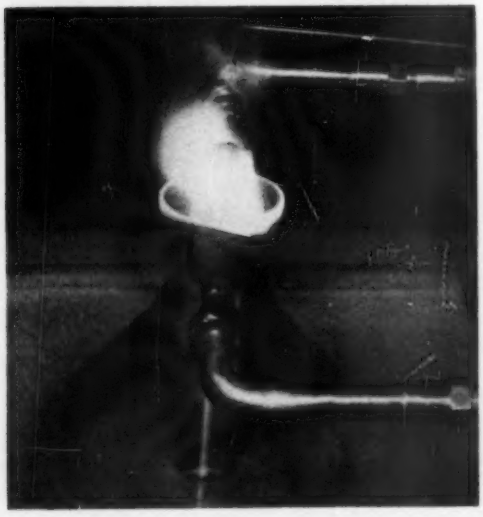
The quenching of locally heated parts now gets more attention. This is wise, since with the closed system of quench which is often used air pockets can be formed if the water pressure is too high, and steam pockets may be formed if the water pressure is too low. Either of these undesirable features may give rise to patchy or low hardness values. A generally accepted pressure value is around 25 lb/sq in.

Flame hardening

This method is being used more often, due to improved control methods and general mechanization of the equipment. The well-remembered acetylene blow pipe often used for local hardening is now superseded by well-designed burners fed with oxygen/town's gas or oxygen/propane mixtures. There are several distinct advantages gained by the use of town's gas or propane instead of acetylene. With an oxygen/town gas mixture about 90% of the town's gas is consumed at the mouth of the burner whereas with acetylene only 25% is burned at this point, the remainder being burned with secondary air away from the burner mouth and, therefore, being wasted. Furthermore an oxygen/town gas flame is small and as the wavy flame peculiar to oxyacetylene is absent a much closer control of the heating surface can be obtained. Although the temperature of an oxygen/town's gas flame is probably 800°C lower than that of an oxyacetylene flame it is still well above that required for hardening and there is a much less risk of burning. It is also convenient with this technique to arrange for a pre-heating stage where necessary.

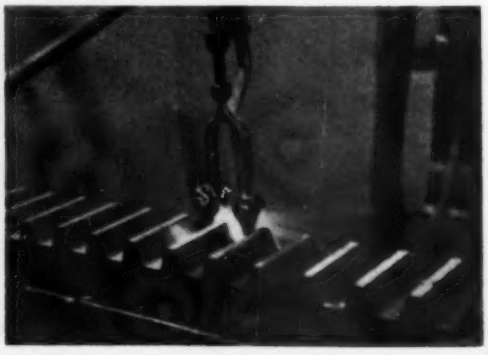
The generally accepted techniques of flame hardening may be divided as follows:

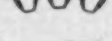
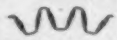
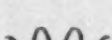
(1) Straight line hardening—used for even surfaces; here the burner, followed by a spray quench, moves progressively along the surface to be hardened.
(2) Spinning—used for circular surfaces of limited width; in this instance the component is spun between burners of suitable width and then drop or spray quenched.
(3) Spinning and progressive—used for cylindri-



21 LEFT *Flame hardening—spin hardening of gear tip* (*Surfard Ltd*)

22 BELOW *Flame hardening—straddle hardening of rack* (*Surfard Ltd*)



D.P.	Flame-hardening Method	Material	Hardened Zone	Applications
5 and smaller	Spinning	En. 8 M		General machine construction as alternative to heat-treated gears
5 and smaller	Spinning	En. 10 En. 24 En. 48		Machine tool construction as alternative to case-hardened gears
6 and larger	Progressive Straddle	En. 8 M En. 9 En. 45		General machine construction as alternative to unhardened or heat-treated gears
6 and larger	Progressive tooth space	En. 8 M En. 9 En. 45		Bevel gears
6 and larger	Progressive tooth-space and Root	En. 10 En. 45 En. 47		Locomotive and tramcar transmissions as alternative to case-hardened gears
	Progressive tooth-space and Root	38 ton cast steel En. 8 En. 8M En. 9		Sprockets

23 *Flame hardening—typical heat patterns (Surfard Ltd)*

cal components where a hardness band cannot be covered by a single burner.

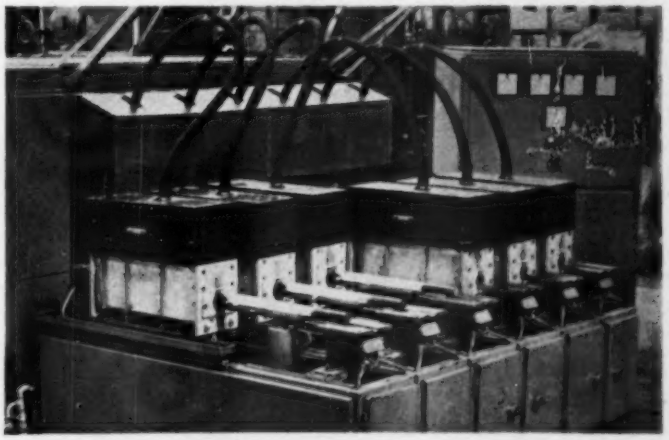
Some typical burner types and flame-hardening set-ups are shown in figs 20—23.

One of the most important items on any satisfactory automatic flame-hardening installation is the temperature-control device. A typical instrument is the radiation type which consists essentially of a lead-sulphide cell which compares radiations being emitted from the object being heated with those from a standard lamp. The response of such an instrument is fast, and it is possible to control the heating cycle in the flame-hardening machine very closely.

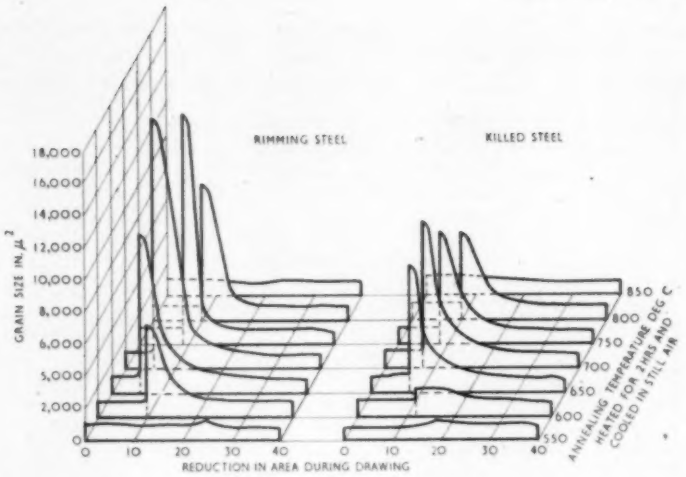
In many instances where flame hardening is to be used it is necessary to consider at which stage the heating process should be undertaken. Flame hardening with minimum distortion is more readily achieved with a component of symmetrical form. Where heating takes place at an intermediate stage it is often wise to modify the machining procedure of the work-piece to get it as symmetrical as possible, *e g* to provide a uniform wall thickness, in order to prevent distortion. It is sometimes possible to leave excess material on a component to provide a balanced section for flame hardening and then to remove the unwanted parts by machining.

Induction heating

There have been many adequate reviews of surface hardening concerned with high-frequency equipment where this is used for local surface



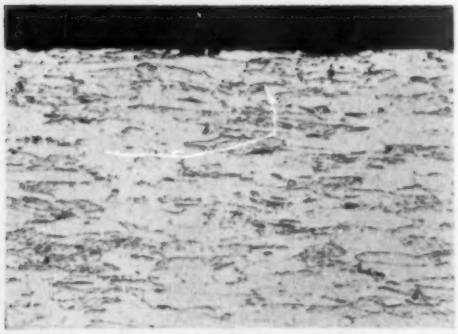
24 *Automatic bar heating by medium frequency (Philips Ltd)*



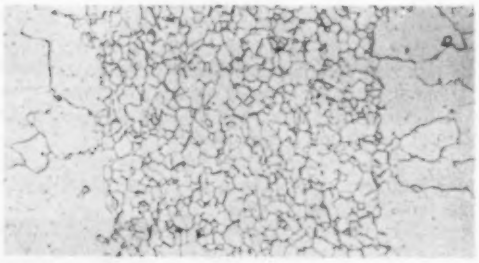
25 *Influence of temperature and degree of cold work on grain size (after Hautman)*

hardening by either the single-shot or by the progressive method. Possibly the most recent developments in induction heating have been those for through heating, where use is being made of medium-frequency equipment provided from motor generator sets which are made with outputs up to 100 k W and can be water cooled and shielded so adequately that they can be positioned in a machine shop and create no undue disturbances from noise.

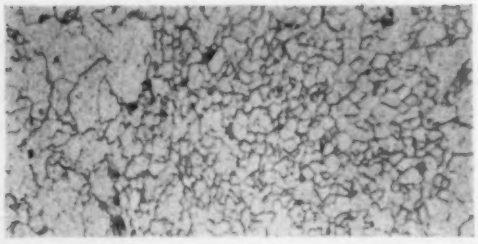
This equipment is generally being used for



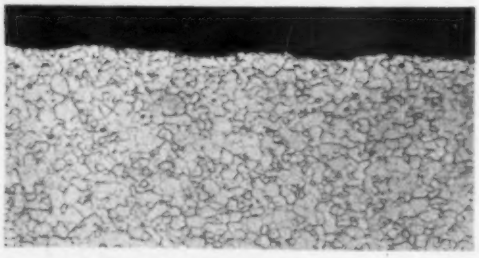
26 *Rimming steel 'as cold worked.'* × 100



28 *Rimming steel annealed for 60 min at 650°C in a tempering furnace.* × 100



27 *Rimming steel annealed for 5 min at 650°C in a tempering furnace.* × 100



29 *Rimming steel annealed for 100 sec at 600°C using 2,000 cycle heating.* × 100

through heating and many installations are working satisfactorily for heating billets or bars for forging, with the obvious advantage of freedom from scale and, consequently, improved die life. A typical installation is shown in fig 24. In this equipment the coil moves over a stationary work-piece.

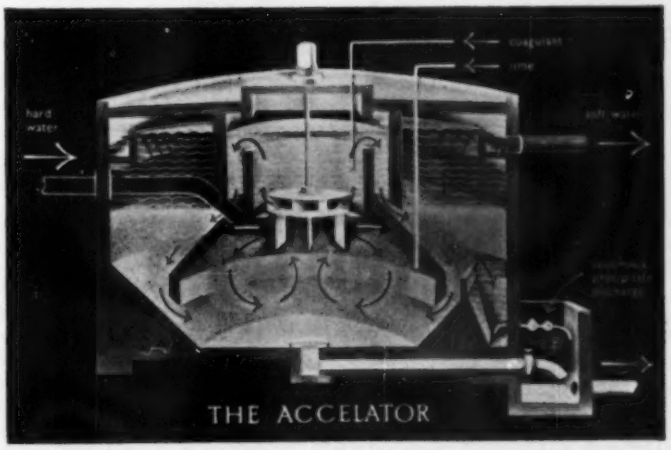
One interesting development in the field of medium-frequency heating is concerned with the annealing of pressings made from rimming steel. Cold-worked rimming steel is very susceptible to critical strain crystal growth when sub-critically annealed in the temperature range 600—650°C, a phenomena which may well render the steel unfit for further pressing operations.

The degree to which grain growth is influenced by temperature and cold work with both 'killed' and 'rimming' steels has been investigated by Hautman and this is well illustrated in fig 25. Advantage can be taken of the quick heat which can be obtained with medium-frequency induction heating in order to avoid this dangerous grain growth. It has been found that cold-worked rimming steel can be softened satisfactorily at low temperatures with heating times as short as 60—100 sec. With the heating time curtailed to this extent grain growth is prevented and there is the additional advantage that the work-piece is free from scale. Figs 27—29 show the micro-structures which are obtained with both conventional and medium-frequency annealing procedures.

References

(1) Rosenthal and Manning, *Trans Amer Soc Metals*, 1947, **39**, 801-815.
(2) Shuval *et al*, *Metallovedenie i Obrabotka Metallov*, 1956, **2** (6), 49-52.
(3) Assonov *et al*, *Vestnik Mashinostroeniya*, 1954, **34** (6), 56-60.
(4) Tarasov and Stetsenko, *Ibid*, 1954, **34** (7), 50-52.
(5) Chenault and Mohnkern, *Metal Progress*, 1953, **63** (4), 97-105.
(6) P. M. Unterweiser, *Iron Age*, 1957, **179** (18), 91-93.

Cleaning slurries



THE ACCELATOR

SUSPENDED MATTER, iron and manganese, calcium and magnesium are all detrimental to many processes using water as a carrier or for direct contact with the product. Steel mills and metal processing plants need to use specially treated water for rinsing metal parts after pickling or plating.

The Accelator plant manufactured by the Paterson Engineering Co Ltd of London incorporates the novel idea of actually allowing precipitation to occur in the presence of comparatively fresh pre-formed slurry, and means are provided for circulating this fresh slurry with the water being treated. Furthermore, provision is made for maintaining this sludge bed in a mobile condition and in such a manner that it actually squeezes the softened water from the bed, thus giving a relatively clear softened water in the upper part of the plant.

In general the plant consists of a vertical and relatively wide diameter main outer steel plate cylinder containing an inner reaction portion formed also of steel plate. The raw water enters by an inlet pipe at the side of the main cylinder and passes to what is known as the agitator hood, a wide diameter circular-closed chamber in the lower part of the main cylinder with a top hood or cover. The upper portion or extension of this hood is a vertical jacketed cylinder of lesser diameter reaching almost to the top of the main cylinder and is known as the secondary main mixing zone, down the centre of which is a vertical shaft driven by a small electric motor at the top of the reduction gear, constituting a vertical paddle shaft. This latter extends to the bottom of the agitator hood chamber or primary mixing zone and is provided with agitators of the rotor type which give a violent agitation.

The chemical reagents (lime and soda ash) enter by a pipe into the top portion of the agitator hood and the action of the agitator gives instantaneous and intimate mixing of the raw water with the reagents and also the slurry which is forced up into the upper secondary mixing zone by the action of the rotor agitators immediately below. Also at the top of the secondary mixing zone coagulant solution (aluminium sulphate or sodium aluminate) is added continuously where a more or less gentle agitation is given by the simple agitators already mentioned, operating in conjunction with the baffles.

Normally the lime and soda solutions are added in the form of a magma, but if required they can be added separately so that in the case of a variable water the dose of either lime or soda can be altered independently to each other. The speed at which the process is carried out by the Accelator is shown by the fact that when samples are taken from the top of the centre tube, it will be found that the reaction is almost complete.

A sample of circulating slurry from the centre tube, when allowed to settle in a cylinder, starts to clear in a matter of seconds and within five minutes the supernatant liquor is clear.

Area of works for subsequent expansion can be seen on left

Henry Wiggin & Co plant developments

Production of high-temperature alloys at Hereford

THE HEREFORD WORKS of Henry Wiggin & Co Ltd, which were shown to members of the Institute of Metals recently, were built originally for the Ministry of Supply as a strategic plant for the production of Nimonic alloys. Erection of this initial plant commenced in 1951 and consisted essentially of two 3,500-lb induction melting furnaces, a 5,000-ton extrusion press and hot- and cold-sheet mills. The first ingot was extruded in 1954.

In 1956, the company purchased the works from the Ministry of Supply with the aim of concentrating all production there and, at the same time, to modernize and expand production facilities. The first stage of this development scheme is now complete with the concentration at Hereford of all production melting and metal recovery activities. It is planned to complete this modernization and concentration by 1965, when the works, laboratory and office buildings will cover approximately 25 acres out of a total site area of 52 acres. At present, the building coverage is about 7 acres, the main production departments, melting, machining, extrusion, hot and cold sheet rolling, maintenance, inspection and stores being accommodated under one roof.

Metal melting equipment

Alloys are melted in induction or direct-arc electric furnaces as follows:

(*a*) Three Birlec induction furnaces each 3,500-lb capacity. (An additional body of 1,500-lb capacity can be fitted to give a range in size of cast.) Each powered by 750-kW generator, frequency 1,000 c/s.

(*b*) Two Birlec direct-arc furnaces, 3-ton capacity. Swing-roof charged and equipped with four bodies interchangeable between furnaces enabling melting of different alloys without frequent lining changes to be carried out. Power input 2,000 kVA. Output voltage 82—215 volts; 8-in.-dia graphite electrodes. Rammed magnesite hearths; high alumina brick side walls, and Sillimanite brick roofing.

Melted metal is cast into ingots either uphill in clusters, or by the Durville method or by the conventional top casting method, using tundishes in most cases (choice of casting method depends on ingot type and size). Metal for re-melting is sent to Sheppard pig-casting machines, water-spray cooled.

Slags are crushed and ground and passed over Wilfley tables to concentrate the metal shot. The concentrate is then re-melted in a 350-lb Birlec-Detroit rocking-arc furnace and the metal pigged

and assayed. It then joins the incoming metal stocks.

Extrusion press

Cast ingots are machined prior to extrusion, which is carried out on a 5,000-ton Loewy extrusion press. Four Wellman furnaces heated by town's gas to between 1,100°C and 1,215°C serve to raise the ingots to extrusion temperature.

The press produces the following:

(*a*) Round bar for machining and subsequent pressing or forging to rotor blades.

(*b*) Rectangular section for direct machining to finished parts such as stator blades for gas-turbine engines.

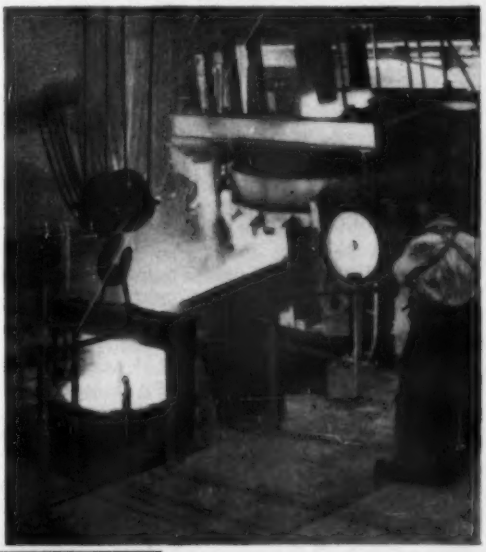
(*c*) Rectangular section as sheet- or strip-bar as starting material for the hot and cold mills, or square section for rod rolling.

The extrusion dies are normally made of 10% tungsten steel, but results with Nimonic 90 are encouraging, particularly when extruding Nimonic 100, and it is expected that Nimonic 90 will be used eventually for all extrusion dies. The die life varies from 30 to 50 extrusions, depending on the section and the alloys under production.

Rolling mills

Hot-rolling equipment consists of a Davy-United roughing mill capable of reducing 2-in. bar to 0·200 in., a Davy-United hot-finishing mill capable of reducing 0·500 in. to 0.080 in. or thinner by pack rolling, three gas-fired furnaces using desulphurized town's gas, a Head Wrightson roller leveller, two Bronx shears, and a Schloemann sheet doubler.

For the production of cold-rolled sheet the following equipment is available: a four-high 300-h p Davy-United reversing mill with a variable speed of up to 150 ft/min (work rolls are 15 in. dia and 44 in. long with back-up rolls 38 in. dia); two Birlec continuous-belt annealing furnaces, one 54 in. wide and the other 32 in. wide, which can operate up to 1,050°C; two Bronx shears cutting 10-ft lengths and one Brookes shears cutting 4-ft lengths, shearing sheet up to $\frac{1}{8}$ in. thick; two Bigwood machines stretching up to $\frac{1}{4}$-in.-thick sheet (sheet is either roller flattened or stretched,



ABOVE *Pouring from one of the Birlec 3-ton electrode furnaces at the Hereford works*

LEFT *Sheet being fed to the hot sheet finishing stand from furnaces*

depending on the alloy and the gauge); and two Ungerer roller levellers which are used, wherever possible, for quicker operations on alloys other than the precipitation-hardening Nimonic series.

Metallurgical laboratories

The laboratories at Hereford are concerned with two main functions: the examination of samples from each production batch to ensure conformation with specification particularly with regard to chemical analysis, mechanical and high-temperature properties; and the initiation and supervision of projects to improve material and processes, particularly the latter.

They are divided into six main sections as follows:

(*a*) *Analytical section* About 70% of all the analytical determinations are carried out on two Hilger quartz spectrographs and a Hilger direct-reading polychromator.

(*b*) *Mechanical testing section* This section, which at present is comparatively small, is equipped with a 50-ton Denison tensile machine, a Houndsfield tensometer, an Avery impact testing machine and Erichsen cupping machines. Testing at room and elevated temperatures is carried out on production material, mainly sheet and strip.

(*c*) *Creep testing section* Every production heat of Nimonic alloy except Nimonic 75 and Nimonic DS is tested before full processing is undertaken to ensure conformation to specification. Further creep tests are performed on samples of the final product before release to the customer. Routine tests are usually carried out at temperatures in the range 750—940° C and stress of 7—21 tons/sq in. The section comprises 60 machines built to specification and three autographic recording machines. Currently about 400 routine creep tests are completed monthly.

(*d*) *Metallographic section* Concerned with a variety of work, from *ad hoc* laboratory and production investigations to long-term development work.

(*e*) *Heat treatment and workshop* Using electrically heated furnaces capable of temperatures up to 1,300° C, the workshop is primarily concerned with the preparation of samples for analysis and tests in the other sections.

(*f*) *Quality control section* This section analyses and reviews technical production records with a view to presenting weekly analyses of yields and rejections to pinpoint aspects of production requiring attention, preparing detailed analyses on selected specialized processes, providing and keeping up to date internal data sheets and specifications for the whole range of production alloys and alloys still in the development stage, and providing a service of statistical analysis whenever it is required.

NEW FILMS

Two films by Mond Nickel

Nickel-alloy permanent magnets

THIS FILM AIMS to demonstrate the properties of nickel alloys for permanent magnets, with particular reference to their stability and strength, and surveys some of the latest mechanical and electrical developments which have been facilitated by these materials.

The introduction reviews the well-known properties of magnets and goes on to show the striking increase in the power of magnet materials developed since the turn of the century. The very high stability of nickel-containing magnets is demonstrated by subjecting an Alcomax magnet to extremes of heat, cold and vibration. Sequences include the manufacture of magnets, electrical and mechanical applications in industry, and Automatic Train Control. The film ends with shots of some of the latest uses of nickel alloys in laboratory standards and nuclear-resonance magnets.

Produced in the studios of the Mond Nickel Co Ltd, the film is a 750-ft 16-mm sound and colour production and runs for 21 minutes.

Spheroidal graphite cast iron

This film, which revises and brings up to date the first film on S G Iron, demonstrates how altering the shape of the graphite in cast iron confers upon it unusual properties of strength and ductility.

Opening with a brief résumé of the advantages and limitations of ordinary cast iron, the film shows how, with the alteration of graphite shape, S G Iron takes on some of the properties of steel while retaining its castability. Reference is made to S G Ni-Resist, a high-expansion, non-magnetic alloy, which is even more ductile than other S G Irons and is resistant to heat and corrosion.

The two main types of S G Iron—Ferritic and Pearlitic—are discussed, with graphs illustrating their stress strain curves. The remarkable ductility of the material in the annealed state is demonstrated and yet S G Iron is seen to be stiffer than ordinary cast iron. Resistance to impact and twisting, machinability, and the versatility of the material in up-to-date applications are illustrated.

The film, produced in the studios of the Mond Nickel Co Ltd, is a 1,000-ft 16-mm sound and colour production and runs for 28 minutes.

The films are available on free loan on application to: The Publicity Department, the Mond Nickel Co Ltd, Thames House, Millbank, London, S W 1.

Alfred Herbert Ltd announces that the company has been appointed sole distributors in the British Isles for measuring and inspection equipment made by Censor of Liechtenstein.

This equipment is made in two types: High-speed, high-precision ball, roller and needle sorting and grading machines for the bearing industry. These are made in a range of types, from the simple machine which accepts good components and rejects plus and minus components, to the more elaborate types capable of sorting into seven different grades and rejecting plus and minus components.

Multi-dimension inspection machines for very small parts.

This equipment is complementary to that made by the Sigma Instrument Co Ltd, Letchworth, for which Alfred Herbert Ltd is the sole distributor.

N A D F S Spring lectures 1958

No 3

Heating for forging

Continuing the series of synopses of the N A D F S Spring lectures for younger members of the industry, we reproduce below some of the main points of the third of the 1958 series given on May 6, in which Mr F. Smith, fuel technologist at the English Steel Forge and Engineering Corporation Ltd, discussed the question of heating furnaces in the drop forge, and showed how thermal efficiency could be raised and kept at a reasonably high level

THE PROBLEM OF HEATING in the drop-forging industry, said the lecturer, was a problem, strangely enough, that could be both simple and difficult, depending on the method of approach. It could be simple if one was concerned with producing relatively small articles, without worrying unduly about the proportion of the cost borne by the heating process. In such circumstances, one could 'get by' with the crudest of furnaces consisting essentially of a box of bricks containing no more than two holes, one for the burner and one for the door. On the other hand, if the heating process was taken more seriously, the problem could become very difficult because heating for the drop forge posed a number of auxiliary problems peculiar to the industry. The main problem, he thought, was the relative lack of continuity of production caused by the jobbing nature of the work, coupled with the necessity for the numerous delays for proofing, etc. This caused wide fluctuations in the rate of output and had a marked effect on heating efficiency, to such an extent that re-heating for drop forging was generally speaking about the least efficient of all hot-working processes in the steel industry.

Requirements of a heating furnace

Drop-forge operatives, said Mr Smith, normally received a certain rate of pay which varied with the type of job in hand, and the contents of the wage packet was a function of the number of forgings produced. When production was held up for making or proofing, the payment usually reverted to the basic or day-work rate and the rate of earnings dropped. After such delays there was a natural anxiety to make up for lost time and a furnace was then expected to provide all the heated stock required to achieve this objective and to provide it quickly. Thus the basic requirements for the design of re-heating furnaces for the industry were:

(1) A high heat-recovery potential necessitating (*a*) the maximum rate of fuel supply which can be burned completely in the combustion chamber, and (*b*) refractories having low thermal storage characteristics.

(2) Provision for pre-heating stock during outage periods for proofing, etc.

Both these basic requirements were consistent with maximum possible production on the one hand and with high efficiency on the other.

High heat-recovery potential, said the lecturer, was essential for a number of reasons, particularly because of its potential effect on fuel economy. Operatives were reluctant to ease off or shut down the furnace while waiting for production to begin again. If it could be demonstrated to them that the furnace had a rapid rate of recovery then they would be more likely to shut down even for short periods. A further advantage was that where plant was in operation for one or two shifts only, then the lighting-up periods could be reduced to the absolute minimum. For high heat-recovery potential low thermal-storage refractories, *i e* hot-face insulating bricks, were a positive advantage, further enhanced with single or double shift working. Such a conception of high heat potential demanded a system of temperature control to avoid excessive temperature heads, wastage of fuel, and what was perhaps even more important, possible overheating of stock.

The second basic requirement was provision for pre-heating stock during outage periods. It was not necessary to stress that production recovery could be accelerated if some stock had been partially heated during the outage period. In the case of drop-forge re-heating, Mr Smith said he favoured load-recuperation in preference to transferring the waste heat to the incoming combustion-air in relatively expensive recuperators which were frequently idling during outage periods and which were exposed to the effects of the hot products of combustion, which could make the life of a metallic recuperator uneconomically short. Similarly, of course, refractory recuperators would be more prone to leakage due to expansion, on account of the high temperature. Also, in the case of oil firing it was not easy to utilize the whole of the recoverable heat, especially with the small furnaces

which formed a high proportion of those employed in the industry. While these observations were generally in line with the opinions of the Association's Furnace Sub-Committee, Mr Smith pointed out that they did not, however, condemn the system of *regeneration* introduced by a well-known furnace builder some years earlier.

Suggested design of a heating furnace

Discussing the design of a furnace which embodied these ideas, Mr Smith said that while double-handling of stock is usually undesirable there were times when the rate of production made it convenient and profitable to use pre-heated billets. There were also occasions when the type of steel being heated demanded a pre-heating stage. At other times the pre-heating chambers in the suggested furnace could be charged at convenient intervals, for example between the shifts, during meal breaks or other temporary stoppages. The suggested type of furnace was therefore a three-chamber furnace of a size compatible with the requirements of at least two stamps in its immediate vicinity. The keynote was flexibility, since it would provide for rapid rates of production for one stamp or for a slower production rate for two stamps. In addition it could provide for one or two stages of pre-heat and this could be done for either of two stamps (see fig 1).

The first furnace-chamber (*A*) would be a re-heating chamber with a high heat-potential and temperature control. It would exhaust to chamber *B* or, if desirable, *via B* to chamber *C*. Essentially it would be a very simple batch furnace with a hearth area capable of maintaining a medium rate of output with the larger uses heated from cold.

Chamber *B* would be a pre-heating *cum* storage chamber without burners and capable of exhausting the waste gases from either chamber *A* or chamber *C* or from both simultaneously away to the stack. Chamber *C* would be essentially a re-heating chamber similar to chamber *A* but providing an exhaust outlet to stack. It could thus be used as a batch-reheating chamber complementary to *A* (exhausting to *B*); as an independent batch furnace for another and adjacent stamp; or as a primary pre-heating chamber, in which case it would not be heated and the products of combustion would travel from *A* through *B* to *C* and thence to the stack.

Anticipated method of furnace operation

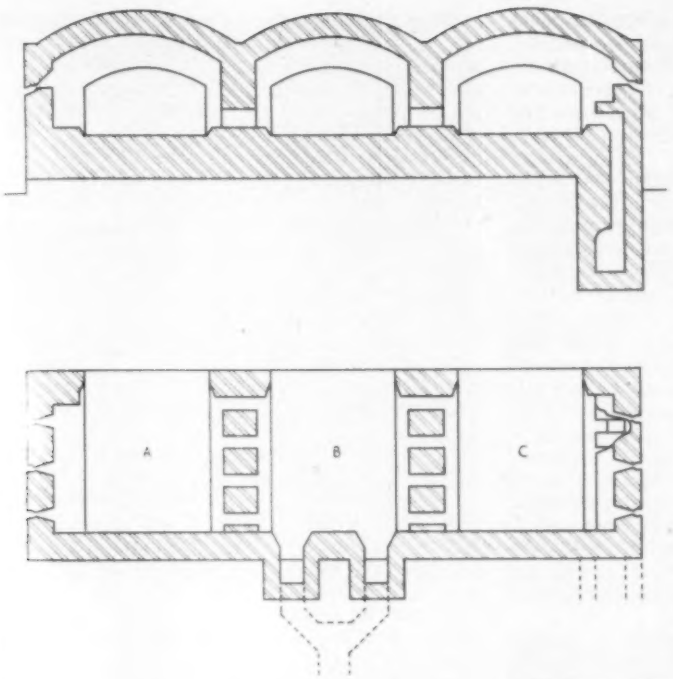
(1) *High rate of production* Chamber *A* is heated as ordinary batch furnace; chamber *B* is receiving products of combustion from *A* and *C* and is used as pre-heater *cum* storage at the discretion of the operators; chamber *C* is heated as ordinary batch furnace.

(2) *Medium rate of production* Chamber *A* is heated as ordinary batch furnace and provides, with the assistance of pre-heated stock from *B*, all the output required; chamber *B* is receiving products of combustion from *A* and *C* and is pre-heating uses for *A*, while chamber *C* is heated as ordinary batch furnace but is heating for an adjacent stamp.

(3) *Slow rate of production* Due to the necessity of pre-heating special steels or to the production of difficult forgings requiring frequent checking, etc, chamber *A* is heated as ordinary batch furnace, chamber *B* pre-heating—second stage, while chamber *C* is pre-heating—first stage, and receiving products of combustion from *A via B* and exhausting to stack.

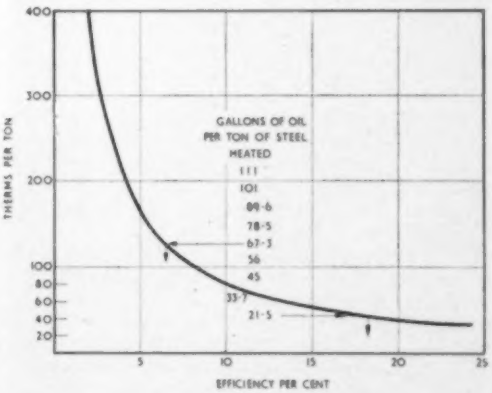
(4) *No production* Due to die-changing, repairs, etc. This perhaps was the most difficult condition to assess in advance and one could foresee varying requirements from complete shut-down to a fully charged chamber *A* for a short break. Generally, however, short of complete shut-down and to avoid excessive scaling, the plan would be to maintain an empty chamber *A* at or lower than normal control temperature with chambers *B* and *C* fully charged for pre-heating. Similarly, chambers *B* and *C* could be fully charged with safety during the lighting-up periods and during meal breaks, thus providing a quick get-away. It would be seen that the plan provided for the utmost flexibility in rates of production and it was during periods of low production that the efficiency of fuel utilization suffered most.

Having stressed the importance of high heat-potential and rapid rate of recovery, Mr Smith turned to consider ways and means of achieving this. There were available numerous well-designed turbulent mixing burners using oil or gas, which would meet the requirements, and in that connection one must not overlook the concentrated combustion burner which in some respects ideally fulfilled the requirements. But, warned Mr Smith, unless the utmost continuity in production could be assumed, concentrated combustion burners were more suitable for heating steel to lower temperatures than those obtaining in the drop-forge industry. Heating steel to temperatures of 1,260°C did not leave a big safety margin before one reached the temperature at which steel could be burned. This did not preclude their use in simple bar furnaces where, if a use was inserted there was more than a good chance that it would be withdrawn and forged before any overheating could occur. Nor did it preclude their use in combustion chambers, large in relation to the size of stock, where good use could be made of the high velocity of the products of combustion. The



1 LEFT *Three-chamber reheating furnace*

2 BELOW *Heat used per ton of steel heated plotted against efficiency (%). Steel heated to 1,260°C.*



danger lay in the massing of the burners in a compact, highly-productive unit.

Value of hot-face insulation

An essential requirement for quick recovery to operating temperatures was, of course, hot-face insulation or low-storage refractories or light-weight refractories as they were sometimes called. The use of such refractories was of the utmost importance in the drop-forging industry, and such use could go a long way towards lifting the efficiency of the re-heating process to a more respectable level than it at present occupied. Briefly referring to the enormous reduction in heat storage and in heat losses which occurred when using hot-face insulation the lecturer said that, largely due to the use of hot-face insulation coupled with good housekeeping, the efficiency of one of their shops had been raised from 11% to 15%. That figure was the annual figure which included every therm of fuel used throughout the year, lighting-up periods, shut-down periods, etc, which meant that the amount of heat used, expressed as therms per ton of steel heated, had been reduced from 76 to 56. The particular fuel in use in this shop cost about 1*s* per therm, so that the saving was equivalent to about £1 per ton of steel heated for forging, in a shop which had forged as much as 16,000 tons in a full year.

Overall fuel efficiency

Referring to the adverse effect of poor loading in drop-forge furnaces, the lecturer showed that if one plotted fuel consumption per ton against output from a furnace, a curve would be obtained which was fairly flat at high output rates but which rose very steeply at low output rates. In order to

make this a general case fuel consumption could be plotted against efficiency per cent, because the efficiency would vary directly with the output for a given level of fuel input to the furnace and so the resultant curve was virtually the same. The left-hand portion of the curve where it began to rise sharply was the portion on which a large number of drop forges were working. The worst cases, with an efficiency of 4 to 5%, lay on that part of the curve which was almost vertical. At 4% efficiency the oil consumption was about 117 gal/ton of steel heated. At 5% it was 93 gal/ton, and at 6% efficiency it was 78 gal/ton.

To improve the efficiency of a furnace from 4% to 6% was the easiest thing in the world. All one had to do was to go on the shop floor and check that the oil was burning in the furnace and not outside it; cut down lighting-up time a little and shut off the furnace as soon as it was out of use. The result could be a saving of 117 minus 78 or 39 gal for every ton of steel heated or nearly £2 per ton off the heating bill for every ton of steel. A modest target to aim at, suggested Mr Smith, was an operating thermal efficiency of 15%, which gave a fuel consumption of 30 gal of fuel oil per ton of steel forged. Thought and vigilance were all that was necessary.

Mr Smith then reviewed briefly the various other methods of heating for drop forging, including the electric resistance ('hot-rod') system and high-frequency induction, but concluded that in his opinion they were likely to go on using the fuel-fired furnace for a long time to come. In fact, he foresaw a probable increase in the use of oil firing and suggested that more thought should be given to the recovery of waste heat, including the design of oil-firing systems which enabled the air for combustion to be pre-heated to a high temperature; there was scope for development in that direction.

Another possible direction in which improvement might come was the oil gasifier system. The only serious rival to oil was, of course, gas, but the price differential between oil and town's gas would appear to be ever widening, to the detriment of gas. Town's gas, however, was the ideal fuel for drop-forge re-heating, but cost would rule it out in the future unless there were revolutionary changes with the advent of the new gas-making processes now being developed. Alternatively, clean producer gas could well be used, but the capital cost of the necessary installations ruled it out for small plants.

Discussion

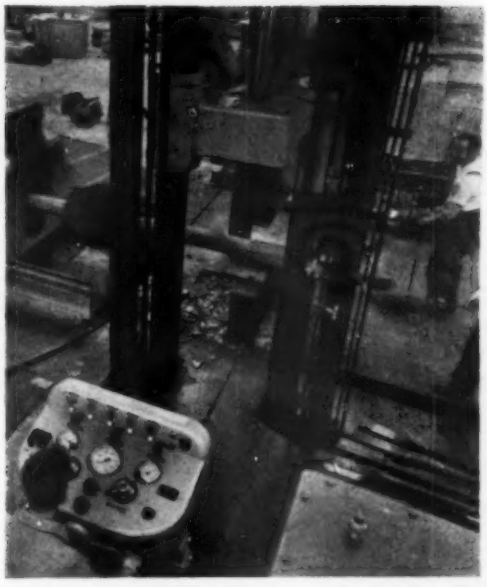
MR R. G. M. MORGAN asked the lecturer to explain the two-chamber reversing furnace which he had mentioned at a previous meeting. Mr Smith said that this was a simple modification of the three-chamber proposal. In effect there would be two chambers interconnected by means of flues in the partition wall. The furnace would be capable of being both exhausted and fired at either end. The principle would be to fire, say, the left-hand chamber from which the stock would be forged. Meanwhile the right-hand chamber would be filled with stock for pre-heating by means of the exhaust gases. At convenient periods the process would be reversed with the right-hand chamber being fired and exhausting into the left-hand chamber and away to stack, the left-hand chamber being filled with stock for pre-heating.

Discussing the subject of metallic recuperators, MR F. C. BIRD said they were certainly capable of lasting ten years and he would assume that the reason the drop-forging industry did not use them was their small size. It was not a practicable proposition to apply metallic recuperator to many small units especially having regard to the vibration, etc, inseparable from the drop forge; but they had been used in this country to heat air to 620° C and in Germany up to 700° C. It was not because the industry lacked knowledge of metallic recuperators, but rather that the drop forge did not seem a useful sphere, having so many small furnaces. Further, in regard to hot-face insulation bricks the vibration factor again had led many people to experiment with springing of small furnaces. Regarding fuels for the drop forge, Mr Bird thought that gasified oil systems were more likely to be applicable to large furnaces than to a battery of small ones, by reason of the fact that unless a number of separate units were applied one to each furnace, there must be inefficiency if 20% of these were out of action due to conditions of supply or demand. Finally Mr. Bird asked the lecturer if he would comment on the nature of the refractory wash he used; was it of aluminiferous cement thinned down or a silicon carbide type ? Regarding hearth construction, did he prefer 37, 42 or 50% alumina refractory bricks and had he any experience with monolithic construction ?

The lecturer replied that he thought a sillimanite type wash was generally used, but in any case one should be guided by the refractory suppliers. With regard to hearth construction he preferred a 73% alumina firebrick for a forging furnace, because it would withstand temperature, wear and tear, and slag attack.

Wickman Ltd in Brazil

Wickman Ltd announces that the company has acquired a majority holding in Brasmac Industria e Comercio S/A, Sao Paulo, Brazil, with a view to furthering the Wickman Group's exports to, and expanding its tungsten carbide interests in, this growing industrial market.



A notable new light forging press

LEFT *Control panel of the 500-ton oil hydraulic forging press*

BELOW *Penetration control valve enabling the press to forge automatically to fine limits*

THE LIGHT FORGE of Walter Somers Ltd, of Halesowen, near Birmingham, was formally opened on October 15, 1958. The ceremony was performed by the Rt Hon Lord Piercy, C B E, the chairman of Industrial and Commercial Finance Corporation Ltd.

In his speech Lord Piercy remarked that the new plant was of the highest degree of technical excellence and reflected great credit on the boldness and wisdom of the board of Walter Somers Ltd, which was notable for the number of young men it contained. On the other hand, the present chairman of the company, Mr Frank Somers, who was the thirteenth child of the founder, could look back upon a very long record of service, having started with the firm in 1898. Throughout their long history the firm of Walter Somers, which began in 1866, had always enjoyed the most excellent labour relations; they had never had a strike, and they operated a profit-sharing bonus scheme.

Plant layout

The building housing the new light forge consists of one main bay 210 ft by 50 ft and two 22-ft lean-to bays. One lean-to bay is reserved for storage, hammer furnaces and heat-treatment furnaces, and is not equipped with a crane, thus avoiding the cost of underground flues from the hammer furnaces. The other lean-to bay forms a steel stock area, and is equipped with a 5-ton floor-

controlled crane. At the top of this bay there is a cold saw and oxy-acetylene cutter for cutting the steel to size before forging. After cutting, the steel is placed on the rotary table for transfer to the forging unit in the main bay. The main bay is arranged with the primary forging unit at the top of the bay at the opposite end to the entrance to the building.

The hammer is located half-way down the bay on the same side as the primary forging unit. The bay is equipped with a 2-ton overhead crane, supplied by Charles Willetts, Jnr, which is available for feeding the treatment furnaces, weighing finished forgings, and despatch. The weighing machine is located in the despatch area.

This layout allows for a continuous flow of material up the stock bay over into the main bay to either forging unit, then back down the shop and out for despatch.

Forging capacity

The production facilities of the new light forge centre around its primary forging unit, which consists of a rapid-acting 500-ton forging press. A secondary 1-ton hammer is also in use in the forge to handle the smallest work.

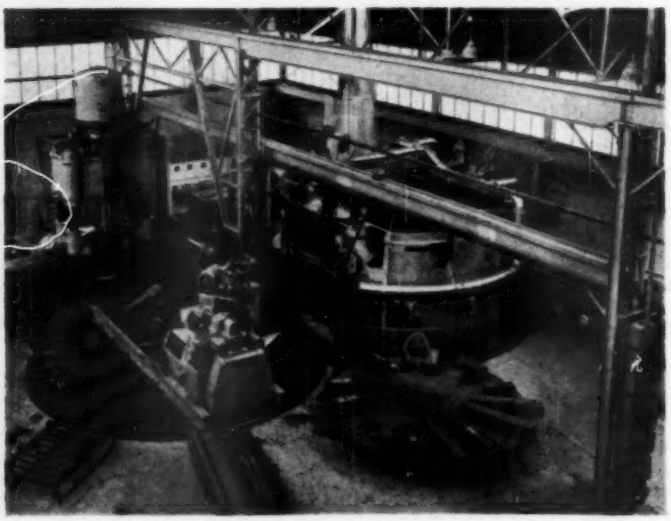
The 500-ton forging press is supplied with heats from a rotary-hearth furnace, and arranged in such a way that all handling, both to and from the furnace and at the press, is carried out by a 4,000-lb manipulator. Adjacent to the furnace there is a rotary stock table from which the manipulator obtains its raw material, and the finished forgings are placed on stillages arranged on the far side of the forging unit from the furnace.

To handle the smallest forgings, there is a 1-ton hammer supplied with hot steel from two solid hearth furnaces, using a charging machine to carry the steel to the hammer. All handling of forgings at the hammer is carried out by hand with the aid of a 10-cwt hoist.

The 500-ton forging press is operated on the Towler oil-hydraulic system. The press structure is a four-column 800-ton shell-piercing press, which has been fitted with new crosshead, main ram cylinder and drawback cylinders, and de-rated to operate at 500 tons. This was felt necessary because of the high speed of operation.

The press was supplied and converted by Reed Brothers. The pumps and control system have been designed to give very rapid operation with an approach and return speed from the work of 16 in./sec, and a forging speed of 3 in./sec. With this control it has been possible to operate the press on small planishing (finishing) strokes of 130 strokes/min. The stroke of the press is fully controlled and with the control lever fully depressed in either the rapid forge or slow forging position, the press will stroke automatically. The lower limit of the stroke can be set from the control desk, so as to maintain a tolerance of $\frac{1}{16}$ in. on the finished size. This thickness control has greatly increased the speed of forging, particularly when the piece approaches its finished size, as the operator does not have to reduce his penetrating speed for fear of forging under size.

Power for the press is supplied by eight oil hydraulic pumps arranged in pairs, each pair driven



View of the main forging unit consisting of 500-ton press, rotary furnace manipulator and rotating stock table

by a 75 h p motor. The maximum oil pressure of the system is 4,500 lb/sq in. with a low pressure control system operating at 1,000 lb/sq in. The low pressure system is supplied by a separate 7½ h p pump.

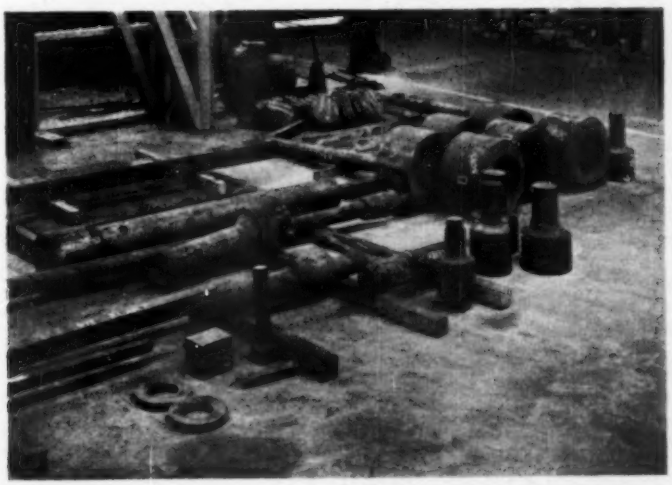
The manipulator

This machine is a large mechanical hand capable of working forgings at the press up to 4,000 lb. It was designed by Kendall Contracting Inc, and built by the Wellman Smith Owen Engineering Corporation. The machine consists of an 18-ft dia rotary table with a 4,000-lb manipulator trolley mounted on tracks on the table. These tracks are arranged so that the unbalanced load carried in the jaws of the machine can be transmitted to the complete turntable, and in this way it has been possible to considerably reduce the weight of the trolley, thus reducing the power required to move it at high speed. A great deal of thought has been given to the speed of this machine, as the time for operating the whole unit is entirely dependent on the speed of the manipulator, the forging press being capable of carrying out its functions much faster than any existent manipulator. This manipulator is used for charging and discharging the furnace, and the operator is located on the turntable at the right-hand side of the trolley. By moving the operator from the trolley itself, he is close to the press at all times, even when forging long bars, and his general comfort is greatly increased as he is not subjected to the vibration of the trolley. The trolley has a maximum travel of 12 ft, and this distance limits the total length of forgings that can be made on this unit. There is a turnabout arranged between the trolley rails on the turntable which can be hydraulically raised in position and hot forgings placed on it and turned through 180°, so that the manipulator may then grip them from the other end. In this way it is possible to finish one end of the forging, turn it around and forge the other end.

The rotary furnace

A 16-ft dia oil-fired rotary hearth furnace is used for heating steel for the press. The furnace operates at 1,250°C, and temperature is automatically controlled. The hearth is arranged to rotate at a speed of 1 r p m. The furnace has a maximum throughput of 2 tons/h. The seal around the rotary hearth is water instead of sand to reduce the drag on the hearth when it is being rotated. The circulation of the water in this seal is controlled thermostatically to ensure that it will not boil and dry out the seal. Rotation of the hearth is powered by an electric motor and reduction gear located in the foundation. The hearth is controlled by the manipulator driver, and the hearth is normally stationary and only moved during the charging or discharging operations. The furnace is not equipped with a centre pillar or baffle wall, as is normal in a rotary hearth furnace, and in fact there is no cool zone.

With the type of work carried out at this press, it is not necessary to pre-heat the steel, and for this reason it is possible to charge directly into a furnace at forging temperature. The choice of a rotary hearth furnace for this application was made entirely to facilitate the handling of steel. Firstly, the large size of the furnace allowed for a very wide door into which the head of the manipulator fits easily, leaving adequate visibility into the



Despatch bay showing typical forgings produced in the light forge

controlled crane. At the top of this bay there is a cold saw and oxy-acetylene cutter for cutting the steel to size before forging. After cutting, the steel is placed on the rotary table for transfer to the forging unit in the main bay. The main bay is arranged with the primary forging unit at the top of the bay at the opposite end to the entrance to the building.

The hammer is located half-way down the bay on the same side as the primary forging unit. The bay is equipped with a 2-ton overhead crane, supplied by Charles Willetts, Jnr, which is available for feeding the treatment furnaces, weighing finished forgings, and despatch. The weighing machine is located in the despatch area.

This layout allows for a continuous flow of material up the stock bay over into the main bay to either forging unit, then back down the shop and out for despatch.

Forging capacity

The production facilities of the new light forge centre around its primary forging unit, which consists of a rapid-acting 500-ton forging press. A secondary 1-ton hammer is also in use in the forge to handle the smallest work.

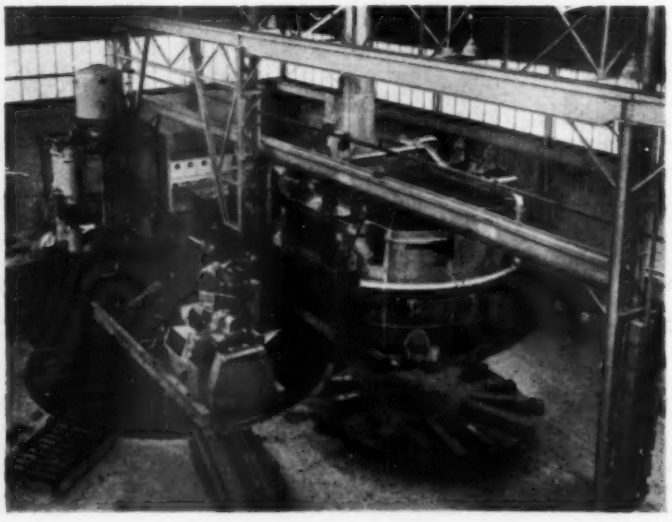
The 500-ton forging press is supplied with heats from a rotary-hearth furnace, and arranged in such a way that all handling, both to and from the furnace and at the press, is carried out by a 4,000-lb manipulator. Adjacent to the furnace there is a rotary stock table from which the manipulator obtains its raw material, and the finished forgings are placed on stillages arranged on the far side of the forging unit from the furnace.

To handle the smallest forgings, there is a 1-ton hammer supplied with hot steel from two solid hearth furnaces, using a charging machine to carry the steel to the hammer. All handling of forgings at the hammer is carried out by hand with the aid of a 10-cwt hoist.

The 500-ton forging press is operated on the Towler oil-hydraulic system. The press structure is a four-column 800-ton shell-piercing press, which has been fitted with new crosshead, main ram cylinder and drawback cylinders, and de-rated to operate at 500 tons. This was felt necessary because of the high speed of operation.

The press was supplied and converted by Reed Brothers. The pumps and control system have been designed to give very rapid operation with an approach and return speed from the work of 16 in./sec, and a forging speed of 3 in./sec. With this control it has been possible to operate the press on small planishing (finishing) strokes of 130 strokes/min. The stroke of the press is fully controlled and with the control lever fully depressed in either the rapid forge or slow forging position, the press will stroke automatically. The lower limit of the stroke can be set from the control desk, so as to maintain a tolerance of $\frac{1}{16}$ in. on the finished size. This thickness control has greatly increased the speed of forging, particularly when the piece approaches its finished size, as the operator does not have to reduce his penetrating speed for fear of forging under size.

Power for the press is supplied by eight oil hydraulic pumps arranged in pairs, each pair driven



View of the main forging unit consisting of 500-ton press, rotary furnace manipulator and rotating stock table

by a 75 h p motor. The maximum oil pressure of the system is 4,500 lb/sq in. with a low pressure control system operating at 1,000 lb/sq in. The low pressure system is supplied by a separate 7½ h p pump.

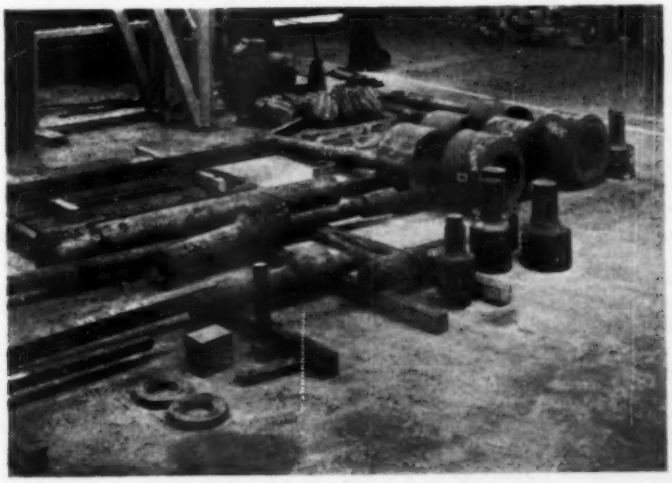
The manipulator

This machine is a large mechanical hand capable of working forgings at the press up to 4,000 lb. It was designed by Kendall Contracting Inc, and built by the Wellman Smith Owen Engineering Corporation. The machine consists of an 18-ft dia rotary table with a 4,000-lb manipulator trolley mounted on tracks on the table. These tracks are arranged so that the unbalanced load carried in the jaws of the machine can be transmitted to the complete turntable, and in this way it has been possible to considerably reduce the weight of the trolley, thus reducing the power required to move it at high speed. A great deal of thought has been given to the speed of this machine, as the time for operating the whole unit is entirely dependent on the speed of the manipulator, the forging press being capable of carrying out its functions much faster than any existent manipulator. This manipulator is used for charging and discharging the furnace, and the operator is located on the turntable at the right-hand side of the trolley. By moving the operator from the trolley itself, he is close to the press at all times, even when forging long bars, and his general comfort is greatly increased as he is not subjected to the vibration of the trolley. The trolley has a maximum travel of 12 ft, and this distance limits the total length of forgings that can be made on this unit. There is a turnabout arranged between the trolley rails on the turntable which can be hydraulically raised in position and hot forgings placed on it and turned through 180°, so that the manipulator may then grip them from the other end. In this way it is possible to finish one end of the forging, turn it around and forge the other end.

The rotary furnace

A 16-ft dia oil-fired rotary hearth furnace is used for heating steel for the press. The furnace operates at 1,250°C, and temperature is automatically controlled. The hearth is arranged to rotate at a speed of 1 r p m. The furnace has a maximum throughput of 2 tons/h. The seal around the rotary hearth is water instead of sand to reduce the drag on the hearth when it is being rotated. The circulation of the water in this seal is controlled thermostatically to ensure that it will not boil and dry out the seal. Rotation of the hearth is powered by an electric motor and reduction gear located in the foundation. The hearth is controlled by the manipulator driver, and the hearth is normally stationary and only moved during the charging or discharging operations. The furnace is not equipped with a centre pillar or baffle wall, as is normal in a rotary hearth furnace, and in fact there is no cool zone.

With the type of work carried out at this press, it is not necessary to pre-heat the steel, and for this reason it is possible to charge directly into a furnace at forging temperature. The choice of a rotary hearth furnace for this application was made entirely to facilitate the handling of steel. Firstly, the large size of the furnace allowed for a very wide door into which the head of the manipulator fits easily, leaving adequate visibility into the



Despatch bay showing typical forgings produced in the light forge

furnace for the driver. Secondly, by moving the hearth it is possible to bring successive pieces of steel in front of the door for the manipulator.

Ancillary equipment

Rotary table The 14-ft dia rotary table is located adjacent to the manipulator turntable, and arranged so that one-half of it is in the steel stock bay. This table serves to transfer the steel from one bay to another, and also gives a small amount of storage for steel between the cutting operation and the forging unit. This storage avoids any possible hold-up of the forging unit when it is in operation. The table was designed to carry 10 tons of steel and rotates at the same speed as the furnace. The table can be controlled either by the manipulator driver or independently from the floor of the shop.

Hammer The hammer is a self-contained Massey 1-ton pneumatic hammer. It is arranged at 45° to the direction of working, so that tools can be used on the forging from either side. The hammer, like the press, is capable of automatic strokes. The power for the hammer is supplied by an 80 h p motor and being self-contained there is no need for steam or a compressed air supply to the hammer.

Hammer furnaces There are two small oil-fired furnaces arranged on the far side of the shop from the hammer. Each of these furnaces is fully automatically controlled and has been built with hot-face insulating brickwork to reduce fuel consumption. The maximum consumption is 8 gal/h.

Charging machine The charging machine is a modified Conveyancer fork-lift truck fitted with a special head for handling forgings into and out of the furnace. The machine is diesel powered and entirely mobile, and can also be used for moving pieces of steel anywhere in the shop within its weight limit, which is 15 cwt.

Heat-treatment furnaces There are two Metalectric electrical treatment furnaces for annealing only. These furnaces are of the bogie type, having a moving hearth 14 ft by 5 ft, and capable of handling a 10-ton load. They are fully automatically controlled. Their maximum electrical consumption is 385 kW. The moving bogies (trolleys) of these furnaces are not equipped with any haulage gear for moving them in and out of the furnace, and a Lansing Bagnall tractor is used for moving them.

The material handling in the forge is carried out with Somers lifting tongs used on the cranes in each bay. There is a Lansing Bagnall tractor and 3-ton trailer, which is used not only for moving material within the light forge but also for collecting steel and delivering forgings from the remainder of the works. This tractor also serves the dual purpose of moving the treatment furnace bogies.

Modernization of forges

A RECENT CONFERENCE arranged by the British Iron and Steel Research Association on the subject 'Modernization of forges' was held at Ashorne Hill, near Leamington Spa, under the chairmanship of Mr F. J. Somers of Walter Somers Ltd.

Three papers were presented for discussion. The first, entitled 'Building a new forge,' was given by Mr A. C. Lowe of Thos Firth & John Brown Ltd, who spoke about the rebuilding of the 1,750-ton press shop at their Atlas Works. He described the factors which had to be taken into account when the question of rebuilding was under consideration, the way in which their new plant was fitted-in with the existing facilities, and lastly gave their present thoughts regarding the layout and operation after some months' working experience of them.

The second paper, 'Features that make for a well-designed modern forge,' was given by Mr E. Homer Kendall of Kendall Contracting Inc, Alliance, Ohio. He stressed the need to allocate separate space to (i) the heating process, (ii) the forging process proper, and (iii) the laying down of completed jobs and any necessary heat treatment, so as to ensure the greatest flexibility in operation and unimpeded flow of work. He then went on to discuss the factors which determine the type of equipment which should be installed in each. His paper contained many references to forge layouts with which he was acquainted which illustrated the points he was making.

The last paper, given by Mr J. Banbury of the BISRA Operational Research Department, was entitled 'A method for comparing alternative ways of forging.' Mr Banbury, referring to work carried out by his department, showed how the method had been used by a company to compare an existing forge with a proposed new forge for the purpose of deciding whether to re-equip. He also described the way in which the same technique could be used for comparing different forges so that cost-and-time-saving factors could be pin-pointed.

The discussion on these papers was extremely lively, indicating the wide interest in the forging industry today in modernization. Latest developments excited particular interest and were further emphasized by the showing of a film of the BISRA experimental forge in which the development of automatic forging is at an advanced stage. A further film by the English Steel Corporation bore witness to the wide range of processes and equipment required in forging.

After the formal conference session, members visited the forges of Walter Somers Ltd, Halesowen, by courtesy of the company, and there saw in operation a new light forge of advanced design.

Gas carburizing and case hardenability

Some basic data

T. W. RUFFLE, F I M

Case hardening is now emerging from a traditional art to a controlled scientific procedure. The author of this article feels that there is now a lack of knowledge of fundamental steel characteristics which would enable more consistent results to be regularly achieved. It is hoped that this work done in the E N V Engineering Co's laboratories will stimulate further thought and investigation along these lines. Mr Ruffle, formerly with E N V Engineering Co Ltd, now represents Ipsen Industries Inc in this country. The first part of this article appeared last month and is concluded in this issue

HARDENING

Having discussed the chemical changes produced in carburizing, we may now turn to the physical properties induced by quenching the carburized material. These are superimposed on the basic natural properties of the *uncarburized* material and, to set the stage correctly, we must first cover briefly our available data on this point.

This is mainly dealt with by the ubiquitous Jominy test, but in this section it will also be convenient to consider the actual test-piece core-hardness values obtained.

The Jominy test appears to be steadily establishing itself in this country, with or without official blessing, and, although not without its faults, the practical information it provides is surely sufficiently valuable to ensure its much more general adoption—unless we get some startling superior innovation. The author, in common with many others, makes many such tests both for present information and with the object of amassing the necessary background information for the anticipated future tie-up of supplies. In our practice, however, the test is 'Anglicized' to the extent of using V P N (5 kg) in place of Rockwell 'C' and tenths of inches rather than sixteenths.

(1) *Jominy curves* It should be remembered that these are from copper-plated standard specimens, austenitized by passage through the continuous furnace with a final zone temperature of 850°C.

Rather than present a confusion of graphs a summary of the 17 curves is given in Table V, from

TABLE V *Summarized Jominy curves*

Code letter	Specification	V P N at distance (inches)						
		0	0·25	0·50	0·75	1·0	1·5	2·0
A	351	440	335	260	238	228	215	209
G	351	465	365	275	252	235	210	198
B	353	500	455	415	365	335	318	292
H	353	475	377	295	270	260	240	235
C	355	475	465	465	455	420	360	350
J	355	540	457	460	450	430	398	370
D	362	490	380	290	260	244	225	217
K	362	510	380	283	252	236	220	209
E	36	440	402	380	335	305	275	265
L	36	435	410	353	320	298	280	275
F	4620	490	425	315	272	252	237	228
M	4620	505	390	270	242	233	220	218
N	8620	480	370	262	240	230	218	205
O	1% NiMo	510	425	285	260	248	240	232
R	CH65J	470	420	355	312	298	288	275

which the general outline may readily be recreated if desired. All the 'pairs' give rather similar curves and conform reasonably closely with *e g*, those given in I S I Special publication No. 56, except for the two for En 353 which are somewhat sharply contrasted. Sample B is normal but sample H has low hardenability for this specification. As a matter of interest, the two 4620 curves are both rather high in relation to the U S A 4620 H range but 8620 (which was, in fact, ordered to 8620H), not surprisingly, is in the standard range.

(2) *Core hardness* Both ½ in.- and 1 in.-dia bars were treated as described previously for all the steels under examination. The core-hardness value, determined at the bar centre midlength for each steel and for each size of bar, is given in Table VI. It is interesting to see with what degree of consistency the core hardness can be forecast from the standard Jominy curve for the same cast; this is examined in Table VI by the reverse process of quoting the actual 'Jominy distance' at which the curves pass through the experimentally determined core-hardness values. The accuracy of location depends very much on the slope of the curve in the area concerned —figures for En 355 have, in fact, been omitted as being too indeterminate to have any value.

TABLE VI *Actual core hardness and 'equivalent' Jominy distances*

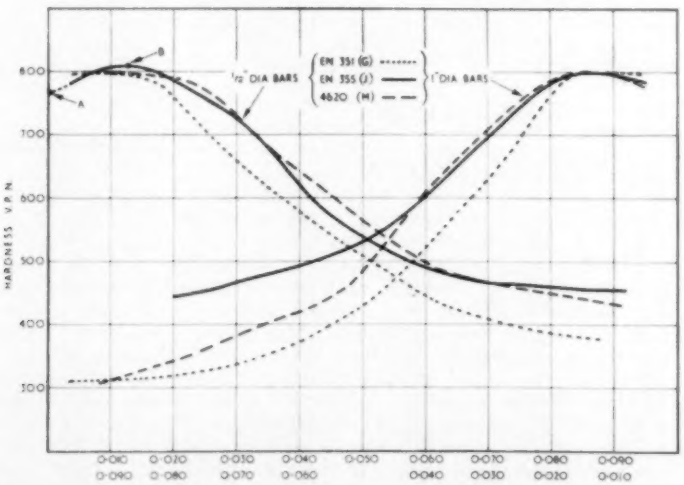
Code letter	Specification	½-in. Bar		1-in. Bar	
		Core V P N	Jominy length	Core V P N	Jominy length
A	351	312	0·28	264	0·47
G	351	380	0·23	308	0·38
B	353	449	0·27	418	0·50
H	353	388	0·23	310	0·40
C	355	444	—	446	—
J	355	448	—	448	—
D	362	370	0·26	285	0·50
K	362	396	0·22	297	0·43
E	36	404	0·26	402	0·26
L	36	394	0·31	338	0·60
F	4620	432	0·21	334	0·44
M	4620	394	0·24	280	0·45
N	8620	334	0·31	261	0·50
O	1% NiMo	451	0·21	310	0·40
R	CH65J	442	0·10	352	0·48

'Core V P N' = V P N (50 kg) at centre midlength of bar size stated
'Jominy length' = Distance from quenched end to 'core V P N' figure

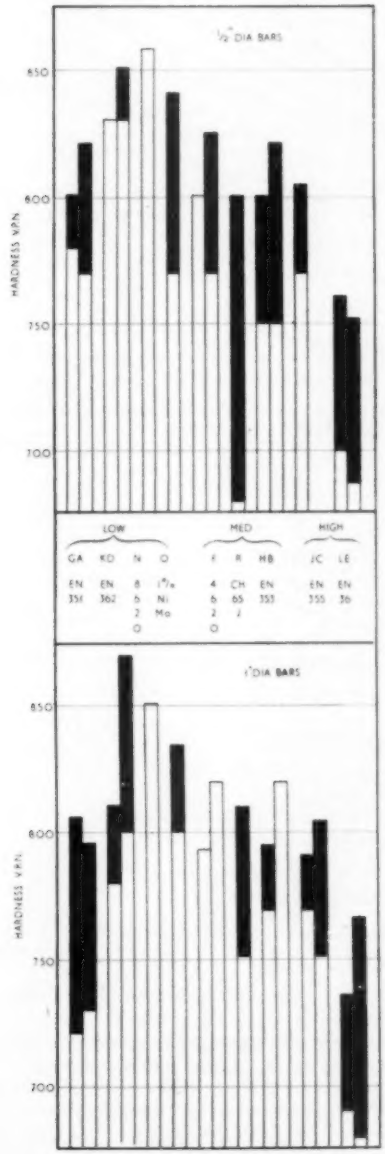
The tabulated figures show appreciable variation —for ½ in. dia, the average 'length' is 0·24 in., range 0·10/0·31, and for 1 in.-dia bars, 0·45 in. average, range 0·26/0·60. There seems to be no correlation between alloy content and the 'length' in this sense.

Other estimates of the Jominy distances equivalent to bar diameter are available, but individual standardization is obviously desirable in view of differences arising from various classes of materials, austenitizing procedures and, especially, the oil-quench details for the comparison bars. (For the present bars under discussion, this comprises a steady lowering from an atmosphere-filled vestibule (hence with a scale-free surface) together with a tray load of work into a vigorous upward current of oil at 40/50°C initially.)

If we now proceed in the reverse direction and use our average lengths of 0·24 in. and 0·45 in. respectively to determine the expected central core hardness for ½ in. and 1 in. bars for all the specimens (except En 355), we find for the ½ in. size maximum errors of +41 and —22 with eight out of 13 within



10 *Typical case-hardness gradients*



11 *Maximum and surface hardness values from case-hardness gradients*

±16 V P N. For the 1 in. size, corresponding statistics are +29 and −21 with 10 out of 13 within ±16. This order of accuracy seems adequate for normal control purposes and it seems that a reasonable working correlation exists for the sizes considered and this particular furnace and quench procedure.

Case-hardness gradient characteristics

The ½ in.- and 1 in.-dia bars, whose core-hardness values have been dealt with above, were carburized, and, in addition to the core hardness, the variation in hardness with depth through the case was also determined with much care. This is done by 5 kg V P N testing on a mounted cross-section metallographically polished, the results being plotted as a curve. This is probably the most valuable single picture one can have to depict the nature and quality of case hardening.

Once again to print the whole collection of curves is impracticable. Those for both ½ in. and 1 in. bars for three steels, low-alloy En 351, medium-alloy 4620 and high-alloy En 355, are shown in fig 10 as representative examples.

Various aspects of these curves are examined in the following sections.

Depth to 500 V P N

This is a frequently used practical definition of our elusive friend ' case depth ' and is often the meaning assigned to ' effective case depth.' We find in practice, too, that the depth indicated by direct measurement on a fracture surface etched in 5% Nital corresponds generally remarkably well with the ' 500 V P N Point.'

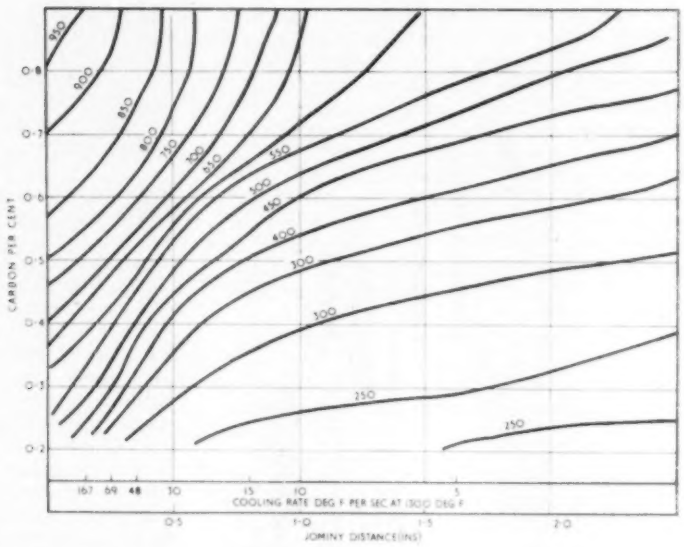
A brief glance at fig 10, however, will show that such a definition should include consideration of test-bar size, especially for lower alloy materials. Examining the effect of bar sizes of ½ in. and 1 in. dia on the depth to 500 V P N, we find the following result (inches) :

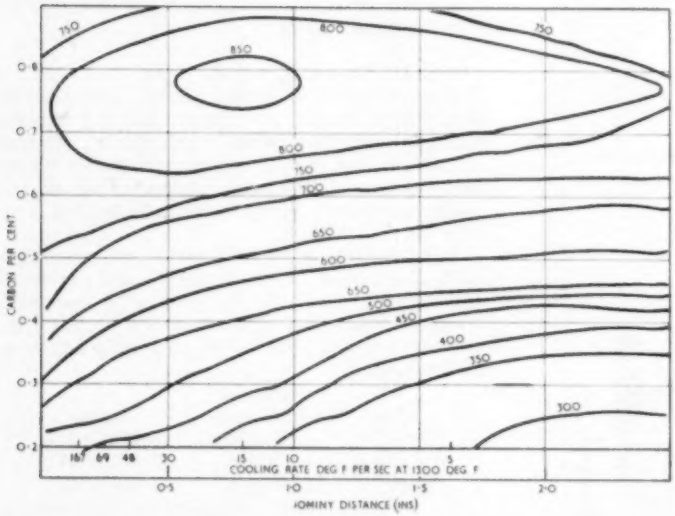
Alloy	Average difference	Range
Low	0·010	0·004/0·017
Medium	0·006	0·001/0·011
High	0·003	0·001/0·006

On low-alloy steels, therefore, in the 0·060 in. case-depth range, a change from ½ in.- to 1 in.-dia test piece can make a variation in apparent ' effective case depth ' of the same order as a normal total tolerance. Consideration of the relation of test-piece size to component size is also obviously desirable.

It is interesting to compare this measurement of case depth with the ' apparent case depth ' determined by the procedure previously outlined based on carbon determinations. As would be expected the ' effective depth ' is lower to an extent depending

12 *Isohardness curves* 8620





13 *Isohardness curves En* 353 (*B*)

appreciably on the alloy content of the material. Analysing the results for 1 in.-dia bars we derive the following summary:

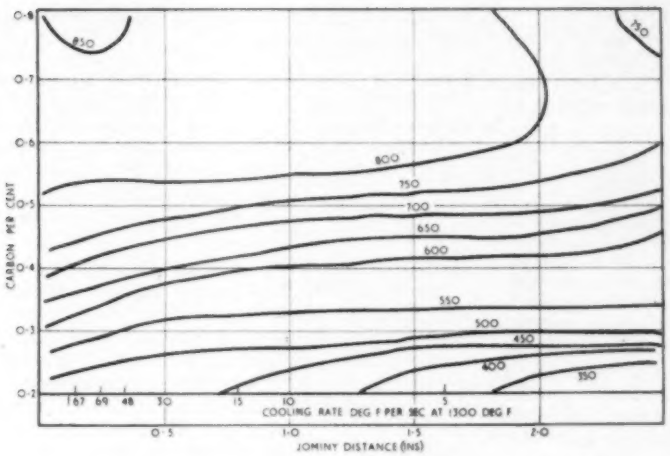
Difference between 'effective' and 'apparent' case depths (inches):

Alloy	Average	Range
Low	0·017	0·006/0·021
Medium	0·011	0·008/0·016
High	0·009	0·001/0·017

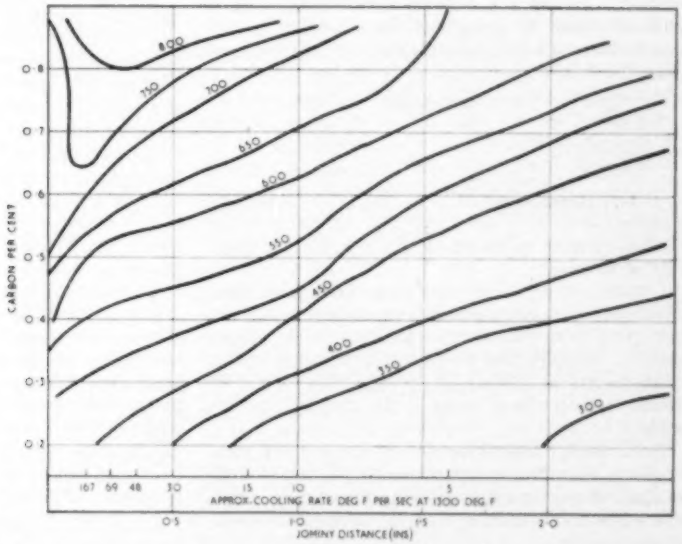
The carbon content at the 500-V P N 'level' is also a matter of interest and this has been examined by cross-reference to the carbon gradients. The

TABLE VII *Carbon content at* 500 *V P N level*

	Low alloy	Medium alloy	High alloy
½-in. Bar	0·31 { 0·29 / 0·37 }	0·28 { 0·26 / 0·29 }	0·26 { 0·25 / 0·28 }
1-in. Bar	0·38 { 0·33 / 0·42 }	0·30 { 0·28 / 0·34 }	0·29 { 0·26 / 0·34 }



14 *Isohardness curves En* 355(*J*)



15 *Isohardness curves En* 353(*B*), *double quenched*

results are shown on Table VII and are of some value in indicating the order required at various levels of alloy content and with varying section size.

Maximum hardness and surface hardness

Maximum hardness is used in the sense of the highest hardness reached by the experimentally determined hardness-depth graph; surface hardness is used here in the sense of the hardness indicated by extrapolating this graph to the surface.

The results for both $\frac{1}{2}$ in.- and 1 in.-dia bars are depicted graphically in fig 11, the surface hardness being indicated by the height of the unshaded column (point A in fig 10 for curve J$\frac{1}{2}$ in.). Where the curve passes through a greater hardness below the surface, the maximum point is shown by the additional shaded column (see point B in fig 10).

Less consistency is found in these results and further work would be desirable on the degree of variation due to various factors such as grinding and hardness test errors. Some useful indications can be derived from average studies, however.

If we take the maximum hardness realized for each specimen, it is found that bar diameter has no

influence on the results of any alloy grade. Fig 11, incidentally, is endorsed to show the arbitrary classification of alloy level adopted by the author for this purpose and throughout the paper. The hardness does vary with alloy content and overall averages are:

Alloy	V P N	Range
Low	827	795/870
Medium	809	795/825
High	773	735/805

Perhaps one should recall here that we are dealing with case structures as developed by direct quenching from 850°C in a continuous carburizing cycle.

Most sections showed some lowering of hardness towards the surface, mainly attributed to austenite formation, but no particular trend can be detected as to the effect of bar size or alloy content on this. Altogether seven gradients (three being ½ in. bars, four being 1 in., three 'low alloy,' and four 'medium alloy') show no apparent drop near the surface. Taking the difference between 'surface hardness' and the maximum for the other curves as a measure of austenite retention, general averages show the following:

Alloy	V P N difference	Range
Low	38	0/85
Medium	38	0/120
High	52	20/85

The increased tendency with high alloy would be expected but it is very difficult to predict the probable degree of austenite retention from normal data otherwise.

Certain compositions seem more favourable than others, but in practice our own experience is that the best plan is to put a test specimen of the given material through the proposed carburizing cycle, standardized as closely as possible, in order to decide if austenite is going to be unduly troublesome.

Incidentally, experience in service showed that, for many important components at least, appreciable retained austenite seems to have no adverse effect and that it need not be viewed too adversely in most circumstances.

One final point in these considerations is the carbon content associated with the maximum hardness developed. On the seven curves showing no surface drop, this is the content shown in fig 6, ranging for these specimens from 0·87/0·93%. On the other curves, the depth to the point of highest hardness varies from 0·008 in. to 0·020 in. From the carbon gradients, the carbon content indicated for the 'maximum carbon depth' has been determined and the usual averaging procedure followed. The results are set out in Table VIII. The seven samples showing no drop are not included in these averages, which present a fairly consistent picture and indicate the order of carbon content associated with maximum hardness.

TABLE VIII *Carbon content at 'max V P N' level*

	Low alloy	Medium alloy	High alloy
½-in. Bar	0·77 (0·75 / 0·82)	0·69 (0·63 / 0·71)	0·61 (0·60 / 0·62)
1-in. Bar	0·73 (0·68 / 0·80)	0·71 (0·70 / 0·71)	0·63 (0·60 / 0·66)

Special Jominy bars—iso-hardness curves

The eccentric-shaped Jominy bars have already been described and, from tests on these, data is available relating speed of quench, depth below surface or carbon content, and hardness. The problem of depicting three variables simultaneously in two dimensions has been discussed in relation to this problem by Gurley and Hannewald[3] and the procedure they arrived at seems the best choice.

The data is depicted by this method in terms of hardness 'iso-bars' on a chart whose co-ordinates are carbon content and cooling rate. (Both the Jominy distance and a typical translation into cooling rate are quoted for convenience.) From these charts a close estimate is immediately available of the hardness to be expected from the given specimen or type of steel with any added carbon content and at various cooling rates.

Once again a choice has to be made for presentation. Three iso-hardness plots are shown out of those prepared for all the specimens in this programme. They have been selected as depicting the most typical characteristics of their group.

Fig 12 shows the curves for the U S A 8620 steel. Those for both specimens of En 351 and En 362 are reasonably similar and that for 1%Ni-Mo is of the same class but shows a greater tendency to 'closed loops' for the high hardness values. This is equivalent to a tendency to austenite retention, and can be seen more clearly in the next example.

Fig 13 shows the curves for the more normal specimen of En 353. The other En 353 is similar but with lower hardenability. The two 4620 specimens show curves which tend to be midway between those for En 353 and 8620. En 36 tends to match with En 353 rather closely and is nearer to this than to En 355. CH65 J is very similar to En 353 as would perhaps be expected.

Fig 14 shows the curves for one specimen of En 355—the other is similar.

There is one serious drawback to this section of the experimental work in that the carbon content is limited by carburizing at controlled potential and the 'iso-hardness' curves are, therefore, available only to the carbon content actually achieved. Ideally, further tests should be made with richer carburizing, but this programme was designed to cover a range

of objectives and some compromise was necessary.

This method of assessing the case-hardening characteristics of a given composition seems to have much to recommend it without involving an excessive programme of experimental work. It affords an excellent means of comparing alternative compositions, or samples nominally from the same specification range, in their reactions over the whole area of carburizing interest.

Very interesting comparisons are possible, also, between different quenching procedures. This has only been partially explored but fig 15 shows ' isohardness ' curves from a special Jominy bar carburized identically with the previous work but not direct quenched. This specimen was reheated at 870°C and oil quenched, reheated at 800°C and quenched on the Jominy fixture, these being the orthodox double-quench temperatures. There is a very considerable modification of the hardening pattern from the change of quenching procedure.

It is possible to construct, from this data and knowledge of cooling rates and carbon gradient on a given specimen, a forecast hardness gradient, and our exercises in this direction so far show quite reasonable agreement. In such work, dealing with actual components, one must bear in mind the variation in carbon content and carbon gradient to be expected at such locations as, for example, tips and fillets of gear teeth.

Case hardening is emerging from a traditional art to a respectably scientific procedure. The type of furnace equipment now becoming available, allied with modern atmosphere techniques, proper instrumentation and control, makes possible a degree of duplication of practice and consistency of heat treatment never before possible.

Our knowledge of the fundamental related characteristics of the steels we use, and the optimum pattern of results at which we should aim, seems now to be lagging behind. For certain critical jobs, at least, there is genuine need for the establishment of suitable tests and co-operation from steel manufacturers to achieve a level of material consistency to match that now available in the process.

Our hope is that this report of our work at this stage will be of some general interest and perhaps stimulate further investigation, both of the fundamental background to this important heat-treatment practice and of the relation of various technical characteristics to performance both in laboratory tests and in actual service.

Acknowledgments

Most grateful acknowledgment is made to the directors of E N V Engineering Co for permission to publish, and for their most progressive and encouraging outlook on heat treatment. The detailed planning and most of the work was carried out by Mr P. C. Kirby, B Sc, with notable skill and exemplary patience. We must thank the Firth-Derihon Stampings Co Ltd, English Steel Corporation and Samuel Fox for ready co-operation in the supply of sample material.

LETTERS *to the Editor*

Surface hardening

SIR: In your October issue you report a lecture on ' Developments in surface hardening ' given recently to the Wolverhampton and Staffordshire College of Technology by Mr E. Mitchell and I would like to congratulate the author on the presentation of an excellent survey of recent progress in this field. There is, however, one point on which I would like to comment—on page 427, the author states: 'An American practice which would be a welcome development in this country involves the fitting of water-cooled heads (fig 9) to endothermic generators. This cooling head, which quickly cools the gas below its reversion temperature and prevents soot formation, would appear to improve catalyst life.'

I am in full agreement with the author that an efficient water-cooled head ensures rapid chilling of the gas and so prevents carbon monoxide breakdown and soot deposition, but I would point out that this is already well appreciated in this country. So far as my own company is concerned, the water-cooled head has always been a fundamental feature of design and has been included in all generators installed since 1948.

J. McMULLEN

Electric Resistance Furnace Co Ltd,
Netherby, 161 Queens Road,
Weybridge, Surrey.
October 31, 1958.

Institute of Metals

SIR: Under Section 16 of the Finance Act 1958, the membership subscriptions of certain societies approved by the Inland Revenue are deductible from the emoluments of any employment to be assessed for tax if deducted out of those emoluments and the activities of the society are relevant to the employment.

The Institute of Metals has now been approved by the Inland Revenue as a society coming within the terms of this Section of the Act.

The effect of this decision is that members of the Institute of Metals may claim tax relief on their annual subscriptions provided that the activities of the Institute are relevant to their employment.

Will you please give publicity to this decision. I am sure it will be welcomed by members of the Institute and it may encourage others who hesitate to become members to join up.

Incidentally, if you are willing to do so, I would also be glad if you would publicize the fact that the Institute's new financial year began on September 1 and that membership elections take place frequently during the year. Particulars of membership of the Institute and forms of application may be obtained from me at 17 Belgrave Square, London, S W 1.

S. C. GUILLAN, *Secretary*

The Institute of Metals,
17 Belgrave Square,
London, S W 1.
October 10, 1958.

BOOKS

Aluminium windows

Applications Brochure 12, Aluminium Development Association. 10s 6d.

THE USE OF ALUMINIUM for window frames has grown considerably over the past 10 years, during which it has been successfully used for residential, industrial and school buildings. This new A D A publication, addressed to architects and their clients and to builders and those concerned with the choice and installation of windows, describes aluminium window-frame design and illustrates some of the many examples to be seen up and down the country today. Many of the window manufacturers have co-operated in the presentation of this book which, of course, is not specifically addressed to them. In lieu of a British Standard on aluminium windows, the brochure should fill an important function and may be used as a basis of a Code of Practice.

The four main sections of the brochure deal with: types of aluminium windows, materials and methods, installation, weathering and maintenance. The first section consists very largely indeed of photographs, many of which throughout the book are in full colour. The section deals separately with metal sub-frames, sub-sills for sub-frames, window sills and window fittings. The section on materials and methods describes the aluminium alloys suitable for windows, with some emphasis on the advantages given by the extrusion of aluminium into numerous standard and special sections, and also deals very briefly with the appropriate methods of joining and finishing. The section on installation deals with the simple methods adopted at points of contact between aluminium and other building materials, and then, under a separate sub-heading, with glazing.

Radiographs of aluminium welds

Book H3/58. British Welding Research Association. Free to members until February 1, 1959—10s to non-members.

Inspectors, welding engineers, designers and fabricators of aluminium alloys will be interested in a new booklet, published by the British Welding Research Association, which shows how to identify those defects in aluminium fusion welds which can be seen in radiographs. The defects are classified, their origin explained and suggestions for their prevention are made. The booklet was prepared by the senior metallurgists of B W R A helped by a panel of experts from industry.

Many more defects can exist in aluminium alloys than in mild steel, mainly because they can be fabricated by several different processes. The devising of a logical system for classifying these defects is, therefore, a step forward. The book recognizes five groups of defects: (1) Cracks. (2) Lack of fusion, including incomplete root penetration. (3) Voids, including the three types of porosity, uniform, localized and linear, as well as elongated cavities and crater pipes. (4) Inclusions of oxide, flux or metal, the latter usually tungsten but sometimes copper or iron. (5) Imperfect shape, including defects which may, or may not, be seen on visual inspection, depending on the joint design, such as undercut, excessive penetration and root shrinkage.

Surface marks give characteristic shadows in radiographs, and they are, therefore, included though they are not defects.

General indications are given of the ways in which the defects influence joint properties, but except for uniform porosity this is only qualitative. A simple system is given for recording the severity of uniform porosity and its probable effect on joint efficiency.

The Factories Acts

Modern industry demands of management a good working knowledge of the Factories Acts and related legislation. The United Steel Companies, recognizing this need, issued in 1945 a summary of the Acts, written in the language of the layman and bringing together, in a handy reference booklet, the main provisions of the Acts as applying to the iron and steel industry.

This summary has now been revised and brought up to date by the company's safety consultant, Mr N. H. Jones, who is an ex-Deputy Chief Inspector, and served with H M Factories Inspectorate for 42 years. Copies may be obtained, free of charge, by interested persons on application to the Welfare Office, the United Steel Companies Ltd, 17 Westbourne Road, Sheffield, 10.

Transformation characteristics of direct-hardening nickel-alloy steels

The Mond Nickel Co Ltd has published a new edition of its Atlas of Isothermal-Transformation Diagrams of Nickel Steels.

In addition to the isothermal diagrams and end-quench hardenability data previously reproduced, the revised publication incorporates supplementary information in the form of continuous-cooling transformation diagrams. These cover the range of cooling rates involved in the oil-quenching of 1—6-in. dia bars, and help to resolve the difficulties of practical application presented by isothermal data alone.

Nickel exhibition at Cranfield

The properties and uses of nickel, nickel alloys and related materials, is the theme of a four-day exhibition which opens at the College of Aeronautics, Cranfield, on November 18. The exhibition, held by the Mond Nickel Co Ltd, is open to all industrial and commercial organizations in the area.

The exhibition, which includes numerous working demonstrations and displays, is designed to inform engineers, designers, metallurgists and students of the latest developments in this field.

Engineers to discuss vacuum processes

'Vacuum processes in the iron and steel industry' is the theme of the 38th Meeting of the Iron and Steel Engineers Group of the Iron and Steel Institute, which is to be held at the Offices of the Institute, 4 Grosvenor Gardens, London, S W 1, on December 11. This will be an all-day meeting, starting at 10 a m.

In all eight papers are to be presented and discussed, covering vacuum degassing and consumable-arc and vacuum-induction melting methods. The authors of these papers are from Belgium (Cockerill-Ougree), Germany (Bochumer Verein and Dortmund-Hörder Hüttenunion), the United Kingdom (B I S R A, Efco-Edwards, and William Jessops), and the U S A (Bethlehem Steel Company and Utica Metals Division, Kelsey-Hayes Company).

NEWS

Titanium sheet annealing furnace

A LANDMARK IN the metal industry in this country has been the recent opening of the new I C I Metals Division plant at Waunarlwydd, South Wales, devoted to the manufacture of titanium rod and sheet. The continuous electric furnace used for intermediate annealing of the sheet between cold-rolling operations was designed and supplied by G W B Furnaces Ltd, and incorporates several unusual features to cater for the special conditions imposed by titanium sheet. The high cost of titanium makes it particularly important to reduce the amount of scrap, and it has been found that the G W B annealing furnace provides a high degree of consistency both in the quality of the anneal and also of the oxide film on the surface of the sheets. The sheets issuing from the furnace are exceptionally flat, and the even oxide layer is relatively easily and evenly removed.

One of the main considerations when initially putting forward the furnace design for consideration was to ensure that the sheets were as flat as possible on discharge. For this reason, the disc-roller-hearth design was chosen. This comprises a series of shafts running across the full width of the furnace hearth, and on these shafts are fixed a series of evenly spaced discs which inter-mesh from one shaft to the next, thus giving a continuous moving ' bed ' on which the sheets are transported. In the more common type of roller-hearth furnace in which plain cylindrical rollers extend across the furnace width there would, in this case, be a danger that the front edge of the sheets might curl down between the rollers, especially with the thinner gauges.

The furnace has a maximum electrical rating of 195 kW divided into four independently and automatically controlled zones. The incoming supply is fed to each zone through a tapped transformer, and spread evenly over the three phases. By these arrangements, considerable flexibility of control can be obtained so that the furnace can cope with new annealing techniques and variations in the materials being processed, while when the furnace is working well below its maximum capacity, rating reduction has a beneficial effect by reducing undue wear and tear on the furnace contactors.

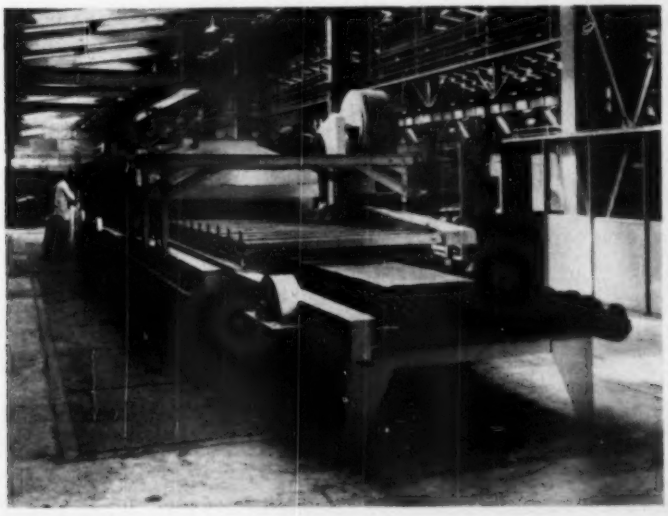
Another useful design feature is that the furnace roof is divided longitudinally into sections which are removable to give easy access for maintenance.

The titanium sheets come in a large variety of sizes and the designed furnace output of 600 lb/h is based on sheets 6 ft by 3 ft by 0·040 in. thick. In addition to initial, intermediate and final annealing of all grades of C P sheet 0·01-0·25 in. thick, this furnace is also used for the final annealing of 317 and 318A alloy sheet. The operating temperature varies in accordance with the particular quality of the titanium sheet, but is normally in the range 700-1,000°C.

The disc rollers at the loading section are rubber covered to reduce abrasive action on the sheets to a minimum, while the disc rollers subjected to heat, are of a suitable heat-resisting alloy to withstand the temperatures encountered; the heated length of the furnace is 30 ft and there is a 16 ft long section extending from the discharge end, the first portion of which is for forced air cooling of the sheets, while the remaining section is for unloading, the rollers in this latter portion being once again rubber covered.

Powder metallurgy

The next meeting of the Powder Metallurgy Joint Group of the Iron and Steel Institute and the Institute of Metals will be held at Church House, Great Smith Street, London, S W 1, on December 16 and 17, when there will be a Symposium on ' The powder metallurgy of ceramic-metal materials.' The meeting will start at 6.30 p m on December 16 with an introductory paper by Dr P. Murray, of the Atomic Energy Research Establishment, Harwell. On the following morning, at 9.30 a m, the main part of the Symposium will begin and will continue until about 5 p m. A series of six papers describing original research work will be presented and discussed.



Titanium sheet emerging from the cooling section at the discharge end of the G W B disc roller hearth furnace. Rubber covered rollers can be seen in foreground

Visitors will be welcome and tickets will not be required.

Papers for this meeting will be published in advance, together with the papers contributed to the first two meetings of the Joint Group and summaries of the discussions on them, in a new publication of the Joint Group which will be on sale by subscription by November. Normally there will be two issues of this publication each year, but for 1958 there will be a double number (1958, Parts 1/2). The annual subscription price, post free, to non-members of the Institutes is £1 5*s* and to members of either the Iron and Steel Institute or the Institute of Metals 10*s* per annum. Orders for this publication should be addressed to the Secretary, Powder Metallurgy Joint Group, 17 Belgrave Square, London, S W 1.

Negretti & Zambra Ltd acquires New Western (Engineering) Ltd

Negretti & Zambra Ltd is acquiring the whole of the share capital of New Western (Engineering) Ltd, the Instrument Installation Engineers and Contractors of Leeds.

New Western (Engineering) Ltd has recently completed the extensions to Calder Hall Nuclear Power Station and have the contracts for the instrumentation for the four reactors at Chapel Cross.

Thomas Marshall & Co (Loxley) Ltd acquires Carblox Ltd

Thomas Marshall & Co (Loxley) Ltd, of Storrs Bridge Works, Loxley, near Sheffield, has acquired the half interest previously held by the Morgan Crucible Co Ltd in Carblox Ltd, which becomes a wholly-owned subsidiary of Marshall.

The members of Carblox Board will be T. Marshall, A. Marshall and W. H. Crawshaw.

English Steel Corporation appointments

English Steel Corporation Ltd announces the following appointments to the Boards of its operating companies:

English Steel Forge & Engineering Corporation Ltd: Mr W. H. Stratford, Assoc Met F I M, superintendent, Steel Melting, and Mr R. W. Brocklehurst, M I Prod E, superintendent, Heavy Forge Production.

English Steel Rolling Mills Corporation Ltd: Mr P. Turrell, who will also hold the office of assistant managing director.

English Steel Castings Corporation Ltd: Mr L. R. Evans, M I Mech E, M I Prod E, superintendent, Foundries.

English Steel Spring Corporation Ltd: Mr R. Fielding, M I Prod E, superintendent, Spring Production.

Change of address

The offices of the British Bureau of Non-Ferrous Metal Statistics have been transferred to 6 Vicarage Road, Birmingham 15. The telephone number and cable address remain unchanged.

Refractory Mouldings & Castings Ltd of Kegworth announces a move to larger premises situated in Market Place, Kegworth. It is hoped that the move will result in an even more efficient service to customers and particularly to those areas of Europe and the Far East to which increased quantities of products are being exported.

Eleventh Hatfield Memorial Lecture

Dr N. P. Allen, F R S, superintendent of the National Physical Laboratory's Metallurgy Division, is to deliver the 11th Hatfield Memorial Lecture on December 9 at the Weir Lecture Hall of the Institution of Naval Architects, 10 Upper Belgrave Street, London, S W 1, at 6 p m.

The lectures, which are given annually in London or Sheffield, were founded in memory of the late Dr W. H. Hatfield, F R S, and are always devoted to subjects in which Dr Hatfield was interested. The subject of this year's lecture will be 'The mechanical properties of the ferrite crystal.'

Dr N. P. Allen was born in 1903 and educated at Burton-on-Trent Grammar School and Sheffield University. Before becoming superintendent of the N P L Metallurgy Division in 1944, he worked at the British Non-Ferrous Metals Research Association, Birmingham University, and the Research and Development Department of the Mond Nickel Company Ltd. He was elected a Fellow of the Royal Society in 1956.

I S I Autumn Meeting to be international

Some of the liveliest discussions during the recent Journées Internationales de Sidérurgie in Belgium took place at Charleroi, when the subject was the continuous casting of steel. It was therefore decided to offer a platform for continuing this debate at the Autumn General Meeting of the Iron and Steel Institute on December 10.

There is to be an all-day meeting on that day at the Offices of the Institute, 4 Grosvenor Gardens, London, S W 1, beginning at 10.30 a m, at which papers from Austria, Belgium, Canada, France, Germany, Switzerland, the United Kingdom, the U S A, and the U S S R are to be discussed. It is hoped to be able to show films of continuous casting in France, the U K, and the U S S R during the course of the meeting.

In addition to and simultaneous with the continuous casting discussion, there will be a session on creep in steel in the morning of December 10 and a joint meeting with the Institute of Welding on hydrogen in weld metal in the afternoon. Both of these meetings will be held at the Weir Lecture Hall of the Institution of Naval Architects at 10 Upper Belgrave Street, London, S W 1.

The 1958 Sir Alfred Herbert Paper

'The European Common Market—its origins and implications' by Sir Cecil Weir, K C M G, K B E, M C, D L.

This paper will be presented in the Lecture Theatre of the Royal Institution, Albermarle Street, London, W 1, on December 11, 1958, at 6.30 p m. (Tea will be served from 5.30 p m.)

The president of the Institution of Production Engineers, the Earl of Halsbury, will preside.

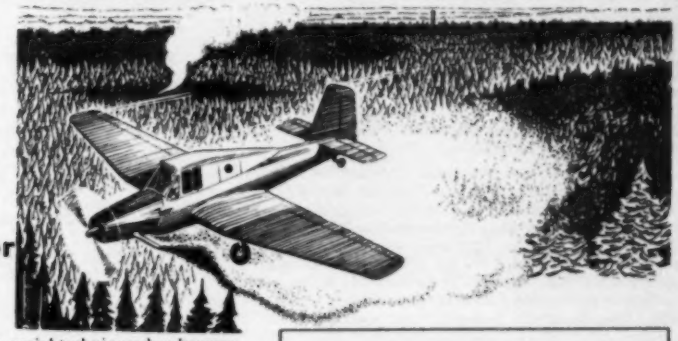
The meeting is open to members of the Institution and their friends, but admission will be by ticket only, which may be obtained from the Institution at 10 Chesterfield Street, London, W 1.

8,000-lb forging manipulator for France

The Head Wrightson Machine Co Ltd, a subsidiary of Head Wrightson & Co Ltd, has just completed the manufacture of an 8,000-lb capacity manipulator, under a license agreement with Salem Brosius, U S A.

Head Wrightson has built a number of manipulators designed for all forging operations, such as furnace charging, transportation of billets from the furnace to the forge press or hammer, and manipulation of work-piece during the forging operation, but this is the first unit to be produced in this country to the latest American design. The manipulator, which was demonstrated recently at Thornaby-on-Tees, is being supplied to France, and is designed to handle rounds or squares from a minimum of 4½ in. to a maximum of 24 in., and this particular machine will be used for forging locomotive axles.

MORE IDEAS BEGIN WITH BORON



Stopping a disaster in its tracks

Restricting the spread of forest fires by aerial techniques has become increasingly important, especially where the use of ground equipment is impracticable. Boron compounds applied from the air isolate spot fires and form chemical firebreaks for the control of established fires. Fire fighting is just one of a wide variety of applications which are being discovered for Boron and its compounds. In nuclear research, rocket fuels and in established fields of industry and pharmacy, the varied properties of Boron and its compounds give rise to many new possibilities.

For further information on Boron and its compounds, write to

BORAX CONSOLIDATED LIMITED

BORAX HOUSE · CARLISLE PLACE · LONDON SW1 · TEL: VIC 9070

BORON IN THE WIRE INDUSTRY

In wire manufacture, the uses for borates are well established. Steel rod or wire is dipped in a hot borax bath to neutralize the last traces of pickling acid and to provide a coating which acts as a lubricant carrier. The process also protects against rust and makes the handling of the wire safer, cleaner and easier.

'20 MULE TEAM' *Registered Trademark*

TGA 8X134

BURDON

The name to remember when you think of Furnaces. Half a century's experience and "know-how" guarantees every installation. We make furnaces of every description including :-

STRESS RELIEVING - HEAT TREATMENT - FORGING - HOT METAL RECEIVERS

BURDON FURNACES LTD.

37 LOCHBURN ROAD GLASGOW, N.W.

PEOPLE

ONE OF THE BEST-KNOWN figures in the field of metallurgy in England, **Dr Harold Moore,** C B E, has recently been elected an honorary member of the Iron and Steel Institute, of which he has been a member for 57 years. Of the 12 living honorary members, only one other, Sir William Larke, is British.

Harold Moore was born and brought up in Middlesbrough, where he was a pupil of the late J. E. Stead. After obtaining his B Sc at London University, he worked for iron and steelmaking companies for some years before joining the Research Department, Woolwich, as chief metallurgist in 1904. In his 25 years at Woolwich Dr Moore saw his department grow into one of the country's leading metallurgical laboratories; during this time and later, he served on many official and industrial committees. In 1932 he became Director of the British Non-Ferrous Metals Research Association, a position he held until his retirement in 1944.

Many technical and scientific institutions have benefited from Dr Moore's support and advice. He was president of the Institute of Metals from 1934 to 1936, and was awarded the Institute's platinum medal; he was the first president of the Institution of Metallurgists; he was treasurer-editor of the Society of Instrument Technology from 1949-1956; he is a Founder Fellow of the Institute of Physics, and has served on the Councils of the Royal Institute of Chemistry and the Faraday Society.

Vice-Admiral Sir Frank Mason, K C B, M I Mech E, M I Mar E, has been appointed a member of the Council for Scientific and Industrial Research.

Sir Frank Mason is a director of Metal Industries Ltd and H. W. Kearns and Co Ltd, and consultant to Metropolitan-Vickers Electrical Co Ltd. He was appointed chairman of the Mechanical Engineering Research Board last June. Before his retirement from the Royal Navy in 1957, Admiral Mason was Engineer-in-Chief of the Fleet.

Sir Donald Bailey, Kt, O B E, J P, Director of the Ministry of Supply's Military Engineering Experimental Establishment at Christchurch, Hants (usually known as M E X E), has been co-opted to the Council of the British Welding Research Association. Quite apart from his high position, Sir Donald is well known as the engineer who invented the Bailey bridge, and is a doctor of engineering of Sheffield University.

Mr George Taylor has been appointed assistant general manager of Head Wrightson Steel Foundries Ltd.

Mr Taylor, who commenced his apprenticeship with the company in 1932, became works manager of their Stockton Branch in June, 1956, at a time when extensive developments in plant and equipment were being undertaken. Mr Taylor is a member of the council of the Tees-side Branch of the Institute of British Foundrymen.

Mr H. N. Wigan has resigned from the Board of the Amber Chemical Co Ltd.

Mr J. Firminger, who joined the company at the end of 1957, and was appointed general manager home sales, is now appointed technical manager.

Mr Firminger had previously held several technical posts, mainly in the petroleum industry, having been in the Esso European Laboratories and the Esso Research Laboratories between the years 1941 and 1948. Additionally, Mr Firminger has had a number of years' experience with British and American concerns, both in producing and marketing fuel additives.

Major-General E. P. Readman and **Miss V. A. Pease** have joined the Board of Amber Chemical Industries Ltd. Major-General Readman has recently retired from the post of managing director of the English Steel Tool Corporation. Miss Pease has been for some time past a director of the Amber Chemical Co Ltd and Charles H. Windschuegl Ltd.

Mr G. J. N. Cherry has been appointed a director and joins the Board of Foundry Services International Ltd.

Mr Norman Addison, who has been commercial director of Head Wrightson Iron Foundries Ltd since its formation in February, 1957, has now been appointed director and general manager of that subsidiary company.

Mr A. P. M. Purdon has been appointed operations study manager in charge of Central Operational Research and Work Study for the British Oxygen Co Ltd.

OBITUARY

Mr Arthur T. Shardlow

An association stretching over the past 64 years with the Sheffield firm of engineers, drop forgers, and crankshaft makers, Ambrose Shardlow & Co Ltd, has been severed by the death last month of Mr Arthur Thomas Shardlow, president of the company. He was eighty-one. Since the days of his apprenticeship at the age of sixteen in the original Washford Road premises, Attercliffe, he had had experience of working conditions at every level of the firm's activities.

Educated at Rossall School, Mr Shardlow joined his father, the founder of the firm, on January 1, 1894, and served his apprenticeship in the pattern-shop, machine shop, and the drawing, estimating, and costings offices. He was made foreman in 1899 and in 1903 was appointed manager of the engineering shop. Following his appointment as managing director in 1905 the company entered the motor trade as crankshaft manufacturers and in 1916-17 he was responsible for the decision to install drop-forging plant.

He was elected chairman of the company in 1939, and last year, in recognition of his long and outstanding service, he was appointed the company's first president. He was one of the earliest members of the committee of the Drop Forging Association, now the National Association of Drop Forgers and Stampers. His keen interest in gardening was reflected in the landscaping which is part of the Meadow Hall Works, and he gave the lead to similar improvements at a number of other Sheffield factory sites.

Dr S. Livingston Smith

The death took place last month of Dr Stanley Livingston Smith, director of research of the British Shipbuilding Research Association. He was sixty-nine.

In 1939 he became superintendent of the engineering department of the National Physical Laboratory and did a great deal of research work throughout the last war. He was made director of research, B S R A, in 1944.

Electro-Heat

The ways in which electricity can be used to advantage in industry are many and varied. Some are well known but others are not known well enough. For this reason the Electrical Development Association has prepared a series of detailed data sheets on various applications which will be printed in this journal from time to time.

This Data Sheet is the first of a number devoted to electro-heat – that is, heat produced by electricity for the processing and treatment of materials. Other uses will be dealt with later on in the series.

There is an unalterable physical law that the efficiency of conversion of *electrical* energy to *heat* energy is 100 per cent. The same cannot be said of the efficiency of combustion of any solid or liquid fuel.

All the applications of electro-heat have these advantages in common:—

1 Electro-heat is clean both in regard to its application and the method of generation.

2 It can easily be controlled more precisely than any other form of heat, manually or automatically.

3 It can be brought to the job instead of having the job brought to it.

4 It permits better use of floor space and the elimination of unnecessary handling.

5 In many of the newer processes it is the only possible form of heat which can be used.

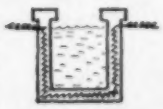
6 It often ensures a higher quality of products with fewer rejects.

7 It gives the best working conditions.

8 It effectively reduces or eliminates fire and explosion hazards.

Below will be found brief notes on some of the various methods of generating heat by electricity.

Resistance Heating



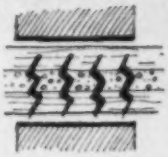
This is the best known form of electric heating. The elements provide a high resistance to the passage of electricity and thus heat is generated. It can be used in furnaces for melting or heat treatment of any material whether metal or not, or the resistance of the workpiece itself can cause the generation of heat.

Induction Heating

Eddy currents are induced in the surface of a conducting workpiece, heating it up. The depth to which this heating will penetrate is determined by the time it is given.

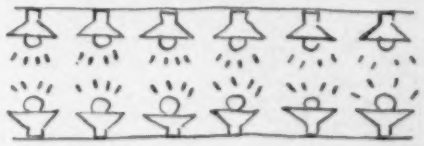
High-frequency Dielectric Heating

This form of electro-heat can be used only on non-conducting materials such as wood, plastic and rubber. The material is placed between two electrodes to which a high voltage is applied at a high frequency. This has the effect of generating heat inside the material rapidly and uniformly throughout its entire thickness.



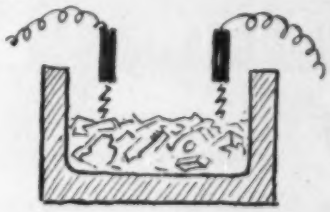
Infra-red Heating

This method employs pure radiant heat. The bulk of the radiation takes place in the infra-red portion of the radiation frequency spectrum. The heaters may take the form of reflector lamps or sheathed wire elements. The method is extremely flexible and has many uses, including paint drying and pre-heating plastics.



Arc Melting

This form of heating is chiefly used for melting steel. The diagram illustrates one method of operation. Very large charges can be melted; melting units of 200 tons capacity are now in operation.



The Application of Electro-Heat

All these methods of electric heating can be applied in almost an infinite variety of ways. Some of these ways will be dealt with in subsequent sheets.

For further information, get in touch with your Electricity Board or write direct to the Electrical Development Association, 2 Savoy Hill, London, W.C.2.

Excellent reference books on electricity and productivity (8/6 each or 9/- post free) are available—"Induction and Dielectric Heating" is an example; "Resistance Heating" is another.

E.D.A. also have available on free loan a series of films on the industrial use of electricity. Ask for a catalogue. 4899/2

Classified Advertisements

FIFTEEN WORDS for 7/6d. (minimum charge) and 4d. per word thereafter. Box number 2/6d., including postage of replies. Situations Wanted 2d. per word.

Replies addressed to Box Numbers are to be sent, clearly marked, to Metal Treatment and Drop Forging, John Adam House, John Adam Street, London, W.C.2.

SITUATIONS VACANT

ASSISTANT METALLURGIST required for laboratory of West London company for investigation of production problems associated with the control of heat treatment and other processes. A knowledge of physical test methods and metallography is necessary and the ability to write concise reports is desirable. Opportunities for advancement in expanding progressive department for person with initiative. Preferred age group: 23-27. Applicants should possess, or be studying for, Higher National Certificate in Metallurgy. Pension scheme, good working conditions and recreational facilities. Apply Box A M 111, METAL TREATMENT AND DROP FORGING.

METALLURGIST required for research and development laboratory. Must be fully conversant with heat-treatment techniques and preferably have a knowledge of metallography and physical methods of analysis. Permanent position with good future prospects. Pension scheme. Apply in writing to: Chief metallurgist, Wild-Barfield Electric Furnaces Ltd, Elecfurn Works, Watford By-pass, Watford, Herts.

MACHINERY FOR SALE

EFCO MUFFLE FURNACES, 18 kW, 1,200°C, 400 volts, three-phase, 50 cycles, complete with Electroflo temperature recorder and controller. Condition as new. Whitefield Machinery & Plant Ltd, Cobden Street, Salford 6. Tel : PEN 4746.

INCANDESCENT 2-CHAMBER GAS-HEATED FURNACE for sale. With air blast, two burners and mixture controller. Keith Blackman 15-in. diameter rotary blower direct coupled to 400 volts, 3-phase, 50 cycles motor. Water gauge and pyrometer, for temperatures up to 1,400° Centigrade. Two chambers one above the other, 9¾ in. × 17½ in. × 6¾ in. high.—F. J. Edwards Ltd, 359 Euston Road, London, N.W.1, or 41 Water Street, Birmingham 3.

MASSEY 2-CWT-SIZE PNEUMATIC POWER HAMMER for sale. Overhanging type with slides. Arranged motor drive 400/3/50. Complete with separate anvil. Longest stroke 14 in. Weight about 55 cwt. Photo, etc, from F. J. Edwards Ltd, 359 Euston Road, London, N W 1, or 41 Water Street, Birmingham 3.

120-TON FRICTION SCREW PRESS by Weston for sale. Double-sided model, 400/100. Welded steel plate construction. Pressure about 120 tons. Max stroke 11 in. Diameter of screw 6½ in. Max daylight ram up 11 in. Arranged motor drive 380/440/3/50. Weight about 5 tons. Photo, etc, from F. J. Edwards Ltd, 359 Euston Road, London, N W 1, or 41 Water Street, Birmingham 3.

'SERCK' OIL COOLER, 750,000 BTU/hr. 1-ton capacity hoist block, complete with swing jib arm suspension. —Whitefield Machinery & Plant Ltd., Cobden Street, Salford, 6. Tel.: PEN 4746.

HEAT TREATMENT

- Capacity for case-hardening is now available in the most modern heat-treatment plant in London
- Gas or pack carburising with full metallurgical control over all operations
- Gleason quenching press equipment for pieces up to 36" dia. plus wide experience in the control of distortion
- Flame-hardening of gears up to 10 ft. dia. with latest electronically controlled equipment

E. N. V. ENGINEERING COMPANY LTD

HYTHE ROAD, WILLESDEN, N.W.10

Telephone LADbroke 3622-3-4-5-6

AP79

DIE SINKING CAPACITY

Offered by Firm engaged solely on Die Sinking and Tool making for the Drop Forging and Allied Industries including Horizontal Forging

•

DIES NORMALLY SUNK IN THE HARDENED AND TEMPERED CONDITION ON CUSTOMERS' MATERIAL IF REQUIRED

Any size blocks up to approx. 12 cwts. each

DIES DESIGNED FOR ANY TYPE OF FORGING PLANT

Fully Comprehensive Modern Plant enables us to offer quick deliveries combined with any limit of accuracy

SAWBRIDGE & CO.

27 TEMPLE BAR · WILLENHALL · STAFFS

Telephone: Willenhall 258

DROP HAMMER BOARDS

SIZES IN STOCK TO SUIT ALL HAMMERS

HB
ESTABLISHED 1867

H. BURBIDGE & SON LTD

Repetition Wood Turners and Machinists

BURNSALL ROAD · CANLEY
COVENTRY
PHONE 72361-2

Dust & Grit Collectors

A new addition to the range of A. & O. dust and grit collectors

This photograph shows an Alldays & Onions UF/1 Dust Collector, primarily for use with hearths and designed to meet the requirements of the Clean Air Act.

ALLDAYS & ONIONS LTD

GREAT WESTERN WORKS · BIRMINGHAM 11
Phone: VICtoria 2251-4

London Office: 2 Queen Anne's Gate, Westminster, London, S.W.1
Phone: WHitehall 1923/4/5

HEAT TREATMENT

Specialised services offered for the treatment of raw and semi-finished ferrous metals

- MANGANESE STEEL CASTINGS
- PLAIN and ALLOY STEEL FORGINGS
- S.G. IRON CASTINGS
- BLACKHEART MALL. CASTINGS
- STEEL BARS - BILLETS - SHEETS

ANNEALERS LIMITED
PENISTONE ROAD - SHEFFIELD 6

THOMAS ANDREWS
AND COMPANY LIMITED
High-Grade Steel Makers

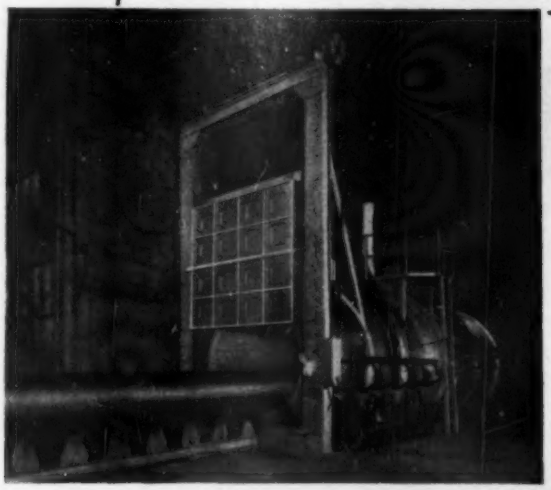
"MONARCH"	*HIGH SPEED STEELS, HOT & COLD DIE STEELS, TOOL HOLDER BITS*
"HARDENITE"	*CARBON & ALLOY TOOL STEELS for ALL PURPOSES*
"HELVE"	*CARBON TOOL STEEL for CHISELS, PUNCHES, &c.*

ROYDS WORKS AND
HARDENITE STEEL WORKS
ATTERCLIFFE ROAD, SHEFFIELD, 4

Export Department
THE HARDENITE STEEL COMPANY LIMITED

Telephone: Sheffield 22131
Telegrams: Shalting, Sheffield, 4

STRESS RELIEVING AND HEATING OF TUBES



Mild steel tubes used between Retorts, Ovens and Purifiers in Gas Works or Coke Oven Plants are liable to Stress Corrosion Cracking. This special circular Furnace can be considered an alternative to the normal bogie design.

It has the following features:

- ★ Charging is by crane on to Roller Table and tube is supported on skid rails in furnace.
- ★ Burners fire tangentially: this causes rapid swirling motion to hot gases.
- ★ Circular chamber and swirling combustion products give uniform heating.
- ★ Length of heated portion of furnace can be adjusted to suit the tube being heated.
- ★ Automatic gas/air proportioning gives high thermal efficiency.
- ★ Furnace of lightweight refractory is quickly heated from cold.

Dowson & Mason Furnaces are used by many major companies. Our technical advisory service is freely at your disposal, and we can submit alternative designs to ensure the most effective answer to your heat-treatment problems.

Illustration shows a furnace 6' 9" diameter in the door opening, 7' 6" diameter in furnace with over-all length of 28' 3" from door face to back of wall.

DOWSON & MASON LTD

ALMA WORKS LEVENSHULME MANCHESTER

Telephone: HEATON MOOR 6251 (5 lines) Telegrams: Gasify, Manchester 19

power hammers WITH A DIFFERENCE

All the hammers in this modern forge have been isolated by installing Mellopad anti-vibration material when the foundation was laid, thus reducing transmitted vibration to a minimum.
Mellopad is recommended by leading hammer manufacturers as suitable ancillary equipment for their machines, also for foundry jolters, drop stamps, etc., and for the isolation of most precision machines.

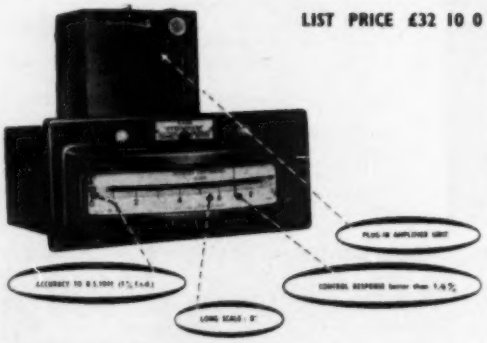
Photograph by courtesy of Messrs. Thos. Firth & John Brown Ltd.

MELLOWES & CO. LTD.

SHEFFIELD · LONDON · OLDHAM

the
SIFAM
PYROMAXIM
electronic controller

LIST PRICE £32 10 0



- RUGGEDLY CONSTRUCTED
- INSTANTANEOUS CONTROL OPERATION
- MINIMUM PANEL SPACE
- ON/OFF INDICATING LIGHTS
- CALIBRATED FOR ANY STANDARD THERMO-COUPLE

Thirty-five years' experience in the manufacture of fine electrical instruments is behind the Sifam Pyromaxim Electronic Controller.

Produced specifically to meet the demand for an economically priced instrument capable of working to high standards of accuracy, this new Controller combines sound design and well-proved construction principles with complete reliability.

Adequate service arrangements are in operation at selected centres.

SIFAM

Write for Folder describing this new instrument in detail.

SIFAM ELECTRICAL INSTRUMENT CO. LTD.
TORQUAY, DEVON, ENGLAND
Telephone: Torquay 4547 *Telegrams and Cables: Sifam, Torquay*

ELECTRO HEAT TREATMENTS LTD.
A. I. D. A. R. B. AND D.I. ARM. APPROVED
BULL LANE, WEST BROMWICH

Specialists in all types of:—
HEAT TREATMENT

BRIGHT HARDENING. Small components; Bolts, Rivets, Washers, Screws and Springs, also large sections up to 3 ft.
BRIGHT ANNEALING. Steel, Stainless Steel, Nickel Silver, etc.
CARBO NITRIDING. For Skin Hardening up to .03 in.
GAS CARBURIZING. Gear Wheels, etc., deep case depths.
LIGHT ALLOYS. Solution and Precipitation up to 10-ft. Sections.
HIGH FREQUENCY. Local Hardening, Annealing, Brazing.
COPPER AND ITS ALLOYS. Chromium and Beryllium Copper, Aluminium Bronze, Solution Treatment, Ageing and Annealing.
GENERAL PURPOSE APPLICATIONS. Treatment of tools, forgings, castings, spinnings, etc., in all alloys.

Telephone and Telegrams: West Bromwich 0584 and 0756

FEL ELECTRIC LTD

Manufacturers of Magnetic Crack Detection, Demagnetising and Non-Ferrous Testing Equipment and Inks

41 Sidney Street, Sheffield, 1
Phone Sheffield 27357/8

HEAT TREATMENT and MECHANICAL TESTING

●

SPECIAL STEEL CO. LTD.
SPECIAL TESTING WORKS LTD.

Managing Director: BENNETT BEARDSHAW, F.I.M.

Annealing and Normalising **Bars up to 24ft. in length**
Oil Hardening and Tempering **Bars and Forgings up to 60 cwt.**
Cold Straightening

MODERN CONTROLLED GAS FURNACES

TESTING **TENSILE · COLD BEND TESTS · IZOD IMPACT**
BRINELL HARDNESS, ETC.
TESTS CARRIED OUT AT ELEVATED TEMPERATURES

Approved: A.I.D. B45587/39 I.A. IA/42/2/41 A.R.D AI/2368/46

BACON LANE WORKS · SHEFFIELD, 9

Telephone 41061-2 Telegrams: Special, Sheffield

Introducing the NEW

Cambridge

CENTRE-LINE INDICATOR-CONTROLLER

The comparatively low cost and convenient small size of this new Centre-Line Controller make it a practical and economical alternative to instruments using saturable reactors, power-positioned variable transformers, and similar expensive control devices.

A time-modulated proportional controller for applications where simple ON-OFF control is inadequate, it forms part of complete CAMBRIDGE equipments for the measurement and control of temperature, pH, gas concentration and other applications. The instrument has an illuminated scale with a novel method of display. The scale is projected optically on to a translucent screen and is adjusted to bring the " desired value " in line with a fixed datum on the centre line of the instrument. The system satisfies the preferences established for indicating instruments by " human engineering " research.

A simple ON-OFF version of this controller employing the same display system and method of error detection is also available.

Send for Lists AW. For future publications ask for Mailing Form AW/9/58

CAMBRIDGE INSTRUMENT COMPANY LTD., 13 Grosvenor Place, London, S.W.1.

STAINLESS STEEL
HEAT RESISTING

ABRASIVE RESISTING
HEAT & ABRASIVE RESISTING

JOFO
CHROMIUM STEELS
MAGNET STEELS

CYANIDING POTS
CASE HARDENING BOXES
CAST IRON, BRASS, GUN METAL
PHOSPHOR BRONZE, ALUMINIUM etc

HIGH SPEED TOOL, DIE
& SPECIAL ALLOY STEELS
also STAINLESS STEEL ROAD
LINES STUDS & SIGNS

HIGHLY ALLOYED STEEL
CASTINGS

'JOFO' castings are available in a wide range of qualities

From a few ozs up to 10 cwts each

M.O.S. approved inspection facilities installed
Routine X-ray control

H. Johnson Foster Ltd.

Head Office: BROADFIELD ROAD
SHEFFIELD 8 (Sheffield 52431)

Foundry: Aizlewood Road, Sheffield
Machine Shops: Broadfield Road, Sheffield

London Office: Central House,
Upper Woburn Place, W.C.1.
(EUSton 4086)

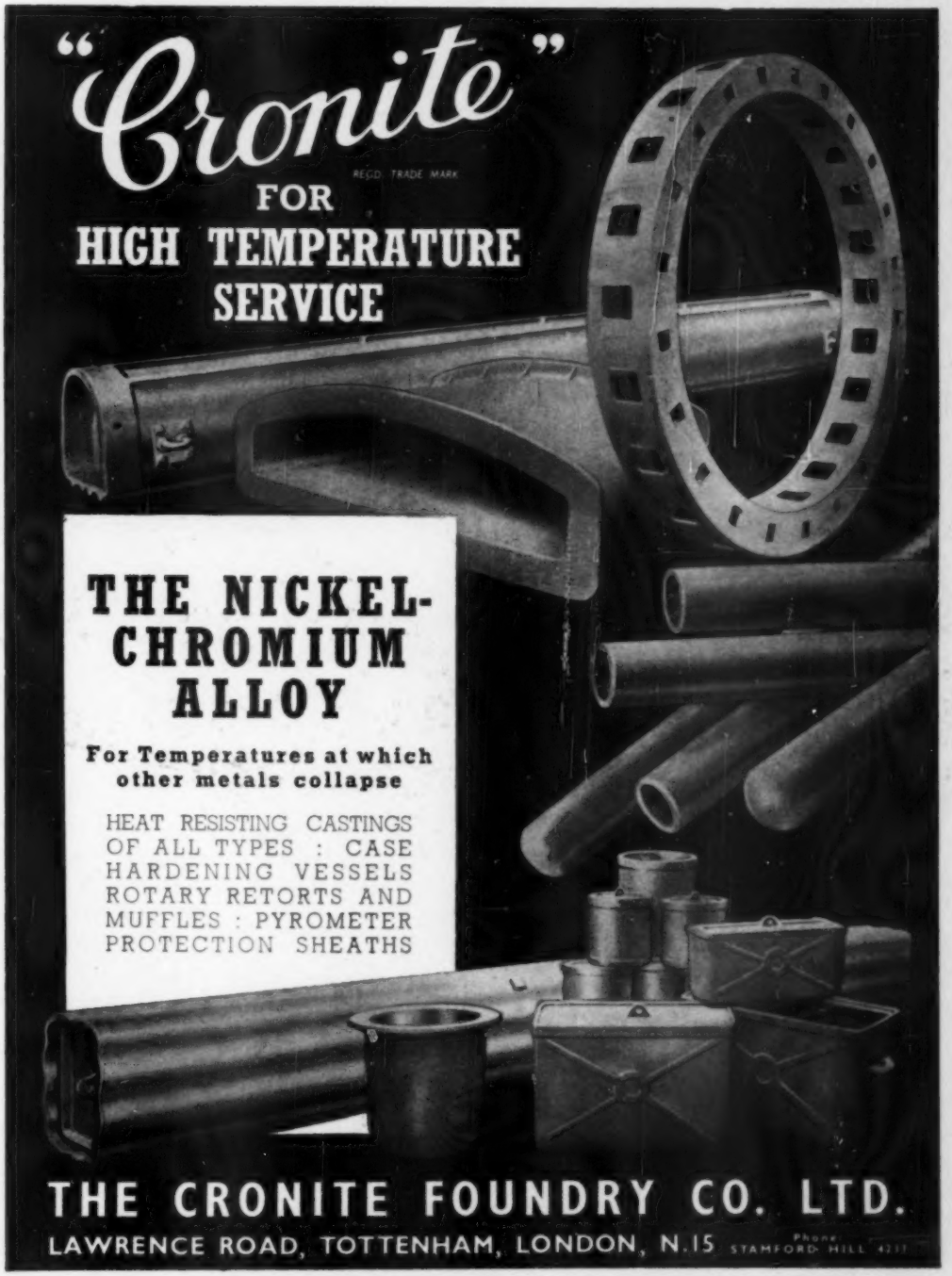
Glasgow Office: 93 Hope Street, C.2.
(Central 8342/5)

H. JOHNSON FOSTER LTD. STEELMAKERS & FOUNDERS

INDEX TO ADVERTISERS

	Page
Acheson Colloids Ltd.	10
Alldays & Onions Ltd.	36
Andrews, Thos., & Co. Ltd.	36
Annealers Ltd.	36
Baker Perkins Ltd.	—
Birlec Ltd.	30
Borax Consolidated Ltd.	485
Bottogas Ltd.	—
Brayshaw Furnaces & Tools Ltd.	12
Briggs Bros. (Engineers) Ltd.	—
Bristol's Instrument Co. Ltd.	—
British Chrome & Chemicals Ltd.	—
British Electrical Development Association	33
British Furnaces Ltd.	21
Broadbent, Thos., & Sons Ltd.	—
Brockhouse, J., & Co. Ltd.	—
Burbidge, H., & Son Ltd.	35
Burdon Furnaces Ltd.	485
Calorizing Corporation of Great Britain Ltd. (The)	—
Cambridge Instrument Co. Ltd.	39
Chambers Bros. Ltd.	—
Climax Molybdenum Co. of Europe Ltd.	—
Clyde Fuel Systems Ltd.	—
Cooke, Troughton & Simms Ltd.	—
Coventry Machine Tool Works Ltd.	28
Cronite Foundry Co. Ltd. (The)	41
Delapena & Son Ltd.	—
Dohm Ltd.	—
Doncaster, Daniel, & Sons Ltd.	8
Dowson & Mason Ltd.	37
Dunford & Elliott (Sheffield) Ltd.	—
Efco-Edwards Vacuum Metallurgy Ltd.	—
Electric Resistance Furnace Co. Ltd.	—
Electro Heat Treatments Ltd.	38
Electroflo Meters Co. Ltd.	—
English Electric Co. Ltd.	—
English Steel Corporation Ltd.	—
E.N.V. Engineering Co. Ltd.	34
Etchells, D., & Son Ltd.	4
Ether Ltd.	5
Eumuco (England) Ltd.	11
Expert Tool Heat Treatments Ltd.	—
Fel Electric Ltd.	38
Firth-Derihon Stampings Ltd.	7
Flame Hardeners Ltd.	—
Fuel Furnaces Ltd.	—
Gandy Ltd.	—
Gas Council	42
General Electric Co. Ltd.	26
General Refractories Ltd.	—
Gibbons Brothers Ltd.	—
Gibbons (Dudley) Ltd.	25
Granby, Paul, & Co.	13
G.W.B. Furnaces Ltd.	—
Hadfields Ltd.	—
Head Wrightson Machine Co. Ltd.	14
Hedin Ltd.	—
Herbert, A., Ltd.	—
Hills (West Bromwich) Ltd.	—
Honeywell-Brown Ltd.	—
I.C.I. Ltd.	19
Incandescent Heat Co. Ltd. (The)	6
Industrial Explosives Ltd.	—
Integra, Leeds & Northrup Ltd.	—
International Furnace Equipment Co. Ltd.	—
Johnson Foster, H., Ltd.	40
Kelvin & Hughes (Industrial) Ltd.	32
Kiveton Park Steel & Wire Works Ltd.	—
Lafarge Aluminous Cement Co. Ltd.	22
Manchester Furnaces Ltd.	24
Massey, B. & S., Ltd.	2
Mellowes & Co. Ltd.	37
Metal Heat Treatment Ltd.	—
Metalectric Furnaces Ltd.	—
Modern Furnaces & Stoves Ltd.	16
Morgan Refractories Ltd.	9
Morris, B. O., Ltd.	—
Newall, A. P., & Co. Ltd.	—
Nitralloy Ltd.	—
Nu-Way Heating Plants Ltd.	—
Plus Gas Co. Ltd.	—
Powder Metallurgy Ltd.	—
Priest Furnaces Ltd.	23
Roberts Bros.	—
Sawbridge & Co.	34
Schieldrop & Co. Ltd.	—
Shandon, E. R., Ltd.	—
Shell-Mex & B.P. Ltd.	—
Siemens-Schuckert (G.B.) Ltd.	18
Sifam Electrical Instrument Co. Ltd.	38
Smethwick Drop Forgings Ltd.	27
Somers, Walter, Ltd.	1
Spear & Jackson Co. Ltd.	—
Special Steel Co. Ltd.	39
Stein, John G., & Co. Ltd.	—
Thermic Equipment & Engineering Co. Ltd.	20
Thompson, Joseph, (Sheffield) Ltd.	—
Vacuum Industrial Applications Ltd.	—
Vaughan, Edgar, & Co. Ltd.	—
Wickman Ltd.	29
Wiggin & Co. Ltd.	—
Wild-Barfield Electric Furnaces Ltd.	3 and 17
Wilkins & Mitchell Ltd.	15
Wykeham, W., & Co. Ltd.	—

Published by the Proprietors, INDUSTRIAL NEWSPAPERS, LIMITED, John Adam House, 17/19 John Adam Street, Adelphi, London, W.C.2, and Printed in Great Britain by F. J. PARSONS, LTD., London and Hastings.


"Cronite"
REGD. TRADE MARK
FOR
HIGH TEMPERATURE SERVICE
THE NICKEL-CHROMIUM ALLOY
For Temperatures at which other metals collapse
HEAT RESISTING CASTINGS OF ALL TYPES : CASE HARDENING VESSELS ROTARY RETORTS AND MUFFLES : PYROMETER PROTECTION SHEATHS
THE CRONITE FOUNDRY CO. LTD.
LAWRENCE ROAD, TOTTENHAM, LONDON, N.15
Phone STAMFORD HILL 4211

metal atment

Vol. 25 : No. 158 NOVEMBER, 1958 Price 2/6

I'm Ringelmann Zero!
You're "in the clear" with
Mr. Therm's Smokeless Coke and Gas.
For expert technical advice on Smokeless Fuel
consult your Area Gas Board.
AND - 11 million housewives cook by GAS!
Issued by the Gas Council